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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 1039

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. ▼ May 5, 1922

EXPERIMENTS WITH CEREALS ON THE BELLE FOURCHE EXPERIMENT FARM NEWELL, S. DAK.

By

JOHN H. MARTIN, Agronomist
Office of Cereal Investigations

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THE CEREAL EXPERIMENTS.[1]

The investigations with cereals on the Belle Fourche Experiment Farm have consisted chiefly of varietal, rate-of-seeding, date-of-seeding, and depth-of-seeding experiments, and the improvement of cereal varieties by the head-selection method. From 1907 to 1911 the

[1] The experiments here reported were conducted on the Belle Fourche Experiment Farm, near Newell, S. Dak., during the 13-year period from 1907 to 1919, inclusive. The experiments were in cooperation with the Office of Western Irrigation Agriculture of the Bureau of Plant Industry, by whom the farm is operated. On April 1, 1912, the cooperative agreement between the Office of Cereal Investigations of the Bureau of Plant Industry and the South Dakota Agricultural Experiment Station was expanded to include the work at Newell. Mr. Cecil Salmon was in charge of the experiments from 1907 to 1913, inclusive; Mr. E. M. Johnston and the writer in 1914; the writer in 1915, 1916, 1917, and part of 1918; and Mr. A. D. Ellison in 1919. Valuable assistance during this period has been rendered by Mr. Beyer Aune, farm superintendent, and Mr. O. R. Mathews, assistant in dry-land agriculture, of the Belle Fourche Experiment Farm. Acknowledgment is here made of the assistance of those mentioned above.

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work was conducted wholly on dry land, but in 1912 a considerable portion of the farm was put under irrigation, and experiments with cereals on irrigated land were begun. The results of these investigations have been reported in part in several previous bulletins of the United States Department of Agriculture and the South Dakota Agricultural Experiment Station.

The results obtained from the experiments on the dry land up to and including 1913 have been published in detail.[2] The work was discontinued at the close of the season of 1919 and all of the important results are published here in order to bring the data up to date and to make the unpublished results from all experiments available. Owing to the widely varying climatic conditions, the yields of the grains show large fluctuations in different seasons. Most of the experiments here reported, however, have been conducted for a sufficiently long period to show quite definitely which are the best varieties and the best cultural methods for growing the various cereals in this region. The results are applicable to a large part of western South Dakota and adjacent portions of northeastern Wyoming, southeastern Montana, and southwestern North Dakota, especially on the heavier types of soil.

The average yields of wheat, oats, and barley obtained on dry land are not large, but might be profitable if seasonal conditions were more uniform. Low yields have been obtained in several years and failures of a part or all of the crops in others. High yields were obtained in 1915 and fairly high yields of some crops in 1908, 1909, and 1918. Grain growing alone is not likely to be successful in western South Dakota, but if carried on in conjunction with stock raising will be profitable some years. Wheat, oats, and barley are more successful than other small grains.

The average yields of the grains on irrigated land are not large. Fair yields of most grain crops were obtained each year and good yields were produced from time to time, so that grain growing has proved successful, especially in rotations with other crops.

DESCRIPTION OF THE FIELD STATION.

LOCATION.

The Belle Fourche Experiment Farm consists of 360 acres located near the center of the Belle Fourche reclamation project in western South Dakota, about 30 miles northeast of the Black Hills. The farm is about 24 miles northeast of Bellefourche and 2 miles northwest of Newell. The latitude is about 44° 43′ 45″ N., and the longitude 103° 26′ 15″ W. The altitude is almost 2,900 feet. Most of

[2] Salmon, Cecil. Cereal investigations on the Belle Fourche Experiment Farm. U. S. Dept. Agr. Bul. 297, 41 p., 12 fig. 1915.

the farm has been under irrigation since 1912, but a portion of it above the irrigation ditch has been used for dry-land experiments. The topography of the farm and of the surrounding country is rolling, affording good drainage, but making irrigation difficult or accompanied by a considerable waste of irrigation water.

A view of the buildings on the Belle Fourche Experiment Farm in 1919 is shown in figure 1.

HISTORY OF THE REGION.

Prior to the discovery of gold in the Black Hills in 1875, western South Dakota was almost undisturbed by white men. Since the early eighties, however, this has been an important grazing region. Farming was confined to the river valleys and the lands adjacent to the Black Hills. The stockmen mowed the wild grasses which grew

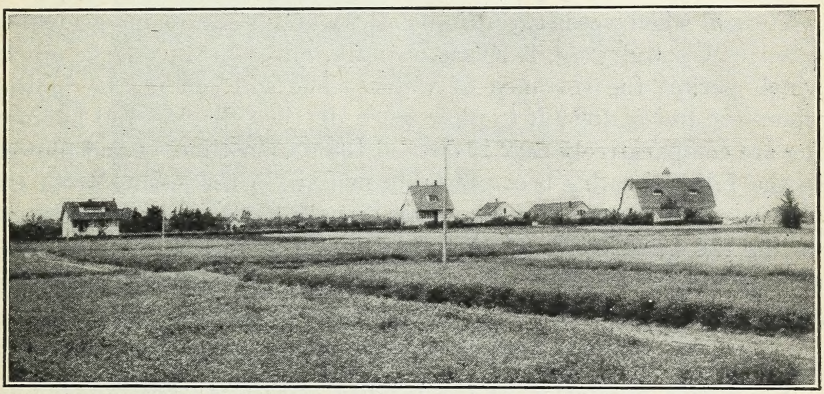

FIG. 1.—Buildings on the Belle Fourche Experiment Farm.

in the low lands on the prairies and fed the hay during the winter to cattle and sheep.

Homesteading in the dry-land region about Newell began about 1908, and within the next three years most of the public land had been taken up. Following a series of dry years, most of the homesteads were abandoned, and to-day the region is devoted very largely to grazing. Some dry farming [3] is practiced, especially in the better favored localities, frequently in connection with stock raising. Along the border of and within the Black Hills dry farming continues to be a successful practice. The Belle Fourche reclamation project has been developed since about 1911. A considerable acreage of cereals is grown each year under irrigation on this and older adjacent irrigation projects.

[3] For a detailed account of dry-farming methods in western South Dakota, see U. S. Dept. Agr., Farmers' Bulletin 1163, entitled "Dry Farming in Western South Dakota," by O. R. Mathews, 16 p. 1920.

On newly irrigated land small grains or flax usually are sown for a cash crop, and on old irrigated land a considerable acreage of these crops is grown in rotations following a cultivated crop or as a nurse crop for alfalfa.

SOIL.

The soil of the Belle Fourche Experiment Farm and of the surrounding section is a heavy, stiff clay, or gumbo, classified by the Bureau of Soils as Pierre clay.[4] This soil occupies about one-third of the area of western South Dakota.

It contains about 35 per cent of clay, 43 per cent of silt, 13 per cent of very fine sand, and only a small quantity of humus. The soil is of residual origin and contains considerable quantities of calcium, magnesium, and sodium salts. Alkali is a problem only in seeped areas.

The soil when wet is exceedingly sticky and is almost impervious to water.[5] Upon drying, it checks rapidly, later forming large cracks which permit the entrance of water. The soil can not be plowed when wet and is difficult to plow when dry, but disking and harrowing are comparatively easy if done at the proper time. Land plowed in the fall when dry becomes quite mellow in the spring from the alternate contraction and expansion caused by temperature changes during the winter. The soil contains ample quantities of plant food and with sufficient rainfall is capable of producing large yields of grain.

NATIVE VEGETATION.[6]

The native vegetation of the locality consists largely of western wheat-grass (*Agropyron smithii*, *A. occidentale*) and buffalo grass (*Bulbilis dactyloides*). Grama grass (*Bouteloua oligostachya*) and needle grass (*Stipa comata*) are frequently found. Buffalo grass usually occupies the higher and lighter soils, especially where Pierre clay is the soil type. Western wheat-grass is confined mostly to the lower slopes and bottoms. On bottom lands subject to overflow this grass produces considerable hay of excellent quality.

Weeds, such as sunflower (*Helianthus petiolaris*), gum weed (*Grindelia squarrosa*), goosefoot (*Atriplex volutans*), and wild parsley (*Peucedanum foeniculaceum*), are plentiful. They are particularly abundant following extremely dry seasons, when the grass may be so injured that weeds are practically the only vegetation. Poverty weed (*Iva axillaris*) is of considerable economic importance because of the

[4] Strahorn, A. T., and Mann, C. W. Soil survey of the Belle Fourche area, South Dakota. *In* U. S. Dept. Agr., Bur. Soils Field Oper., 9th Rpt., 1907, p. 888. 1909.

[5] Mathews, O. R. Water penetration in the gumbo soils of the Belle Fourche Reclamation Project. U. S. Dept. Agr. Bul. 447, 12 p., 4 fig. 1916.

[6] Adapted from U. S. Dept. Agr. Bul. 297, p. 3. 1915.

difficulty of eradicating it in cultivated fields. This plant commonly is called gumbo weed in this locality because it is found usually on the more impervious soils of the Pierre clay type.

CLIMATIC CONDITIONS.

PRECIPITATION.

The precipitation at Newell is very similar to that of most of the northern and western portion of the Great Plains, and especially western North Dakota and South Dakota. Within the Black Hills region the climate is more mild and moist than on the Plains, and

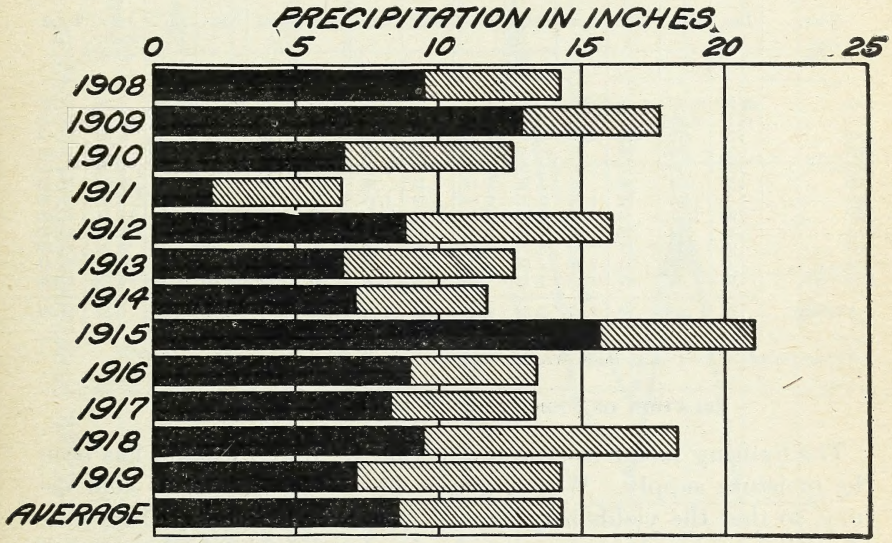

FIG. 2.—Diagram showing the annual and seasonal precipitation at the Belle Fourche Experiment Farm for the 12-year period from 1908 to 1919, inclusive. The solid portion of each bar shows the seasonal precipitation, while the total length of the bar shows the annual precipitation.

the average annual precipitation ranges from 18 to 22 inches. The Black Hills modify the climate of the immediately surrounding country to a great extent, mainly by increasing the precipitation. This effect extends several miles beyond the outlying foothills. The Belle Fourche Experiment Farm is situated about 25 miles from the foothills and, so far as known, is not influenced to any extent by proximity to the Black Hills.

The total annual precipitation at Newell varied from 6.64 inches in 1911 to 21.02 inches in 1915. The average annual precipitation during the 12 years from 1908 to 1919, inclusive, was 14.31 inches. This is believed to be about the normal for the region around Newell. An average of 8.57 inches, or nearly 60 per cent of the total, occurred during the five months from March to July, inclusive. This is ap-

proximately the growing period for the cereals on dry land at Newell. The seasonal precipitation was a prominent factor affecting the yields of grain. The monthly, seasonal, and annual precipitation recorded in inches at the Belle Fourche Farm from 1908 to 1919, inclusive, is shown in Table I. The seasonal and annual precipitation is also shown graphically in figure 2.

TABLE I.—*Monthly, seasonal, and annual precipitation at the Belle Fourche Experiment Farm, 1908 to 1919, inclusive.*

[Depth of precipitation in inches. T=trace.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	March to July, inclusive.	Total.
1908	[a]0.20	[a]0.19	[a]1.65	1.16	3.95	1.47	1.26	0.62	0.52	[a]2.10	[a]0.20	[a]0.91	9.49	14.23
1909	[a].17	[a].23	[a].19	.84	3.87	5.59	2.45	.55	1.07	.76	.73	1.28	12.94	17.73
1910	.73	.70	.93	1.57	1.26	1.51	1.42	1.03	2.92	.27	.11	.10	6.69	12.55
1911	.13	.05	.09	.17	.45	.50	.80	1.86	.92	.39	.98	.30	2.01	6.64
1912	.24	.10	.71	2.32	2.26	.29	3.20	2.80	3.49	.51	.04	.13	8.78	16.09
1913	.57	.24	.99	.25	1.98	3.10	.35	.26	2.38	1.86	.10	.45	6.67	12.53
1914	T	1.00	.29	1.09	2.22	2.09	1.34	1.12	.35	1.77	0	.43	7.03	11.70
1915	.92	1.01	.16	2.58	2.32	4.74	5.74	.44	1.26	1.25	.43	.17	15.54	21.02
1916	.36	.23	.98	.64	3.17	2.19	2.01	2.02	.20	.99	.33	.28	8.99	13.40
1917	.92	.74	.27	2.51	3.71	.97	.80	1.67	.35	.46	T	.92	8.26	13.32
1918	.99	.64	.81	2.40	1.60	1.17	3.41	2.99	3.08	.22	.15	.85	9.39	18.31
1919	.04	.57	.87	2.14	1.14	.35	2.59	1.02	1.20	2.49	1.22	.62	7.09	14.25
Average	.44	.48	.66	1.47	2.33	2.00	2.11	1.37	1.48	1.09	.36	.54	8.57	14.31

[a] From records of the United States Weather Bureau at Vale and Orman, S. Dak.

RELATION OF PRECIPITATION TO YIELDS OF GRAIN.

The limiting factor in crop production at Newell usually has been the moisture supply. Winter grains have been subject to cold injury, so that the yields may depend on several factors. The yields of spring grains, however, are closely associated with the amount and distribution of the rainfall. The precipitation during the growing period is the most important. The amounts and distribution of this seasonal precipitation have largely determined the yields of spring grain on the dry land at Newell. In some seasons, as that of 1912, the rains came too late to benefit the early varieties of grain. In 1910, 1917, and 1919 the lack of moisture during the heading and ripening period caused low yields.

A rain of less than 0.3 inch during the growing season, unless followed or preceded by other rains within 24 hours is of almost no value to grain crops in this section. The moisture from light rains does not penetrate far into the soil and is soon evaporated. In 1911 there was a total precipitation of 2.01 inches during the growing season, March to July, inclusive, but this came in such small and scattered showers that it was useless for crop production. Consequently all grains were a failure that year.

In figure 3 are shown graphically the "useful" seasonal precipitation and the yields of Kubanka durum spring wheat (C. I. No. 1516) during the 12 years from 1908 to 1919, inclusive. The "useful" precipitation shown is the total precipitation in rains of 0.3 inch or more during the period between the emergence and ripening of the Kubanka wheat each year. When the rains occurred during a period of two, three, or four consecutive days the total amounts for the

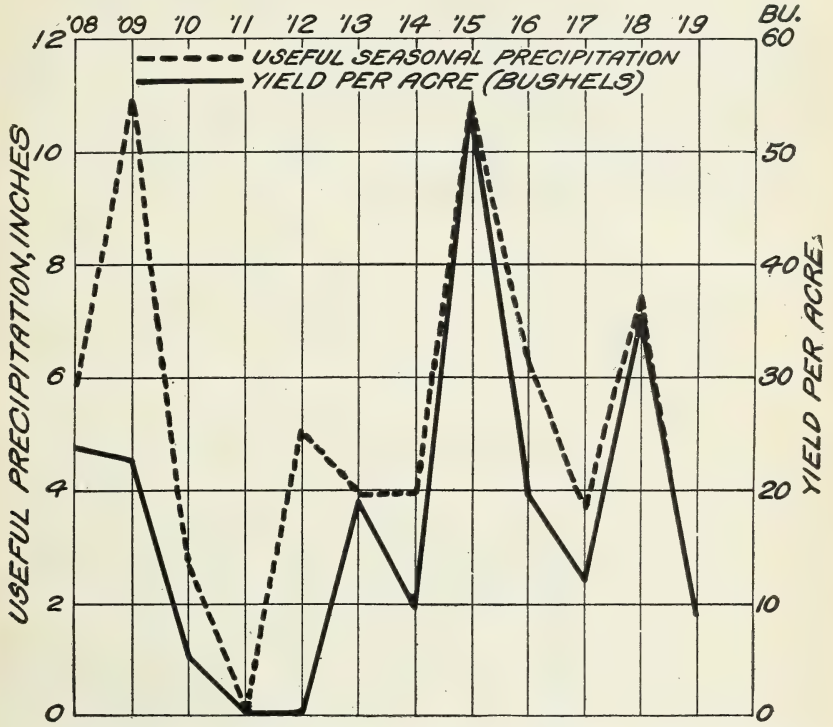

FIG. 3.—Diagram showing the relation between the annual useful seasonal precipitation and the yields per acre of Kubanka durum spring wheat on dry land at the Belle Fourche Experiment Farm for the 12-year period from 1908 to 1919, inclusive. The broken line shows the useful precipitation and the solid line the yields of Kubanka wheat.

period were included even though less than 0.3 inch fell on some of these days. The Kubanka variety of wheat was selected because it was the leading variety, was grown each year, and was not seriously affected by rust.

In figure 3 it will be seen that the yields of Kubanka wheat are closely associated with the useful seasonal precipitation during most of the years. In 1909 and 1914 the wheat was on poorer soil than usual. In 1912 most of the rains came just before the wheat was ripe and too late to be of benefit. The crop was a complete failure in

both 1911 and 1912. The 1913 crop was probably benefited by the abundant late rains in 1912.

EVAPORATION.

The seasonal evaporation probably ranks next in importance to seasonal precipitation among the factors which influence the growth of crops at Newell. The daily evaporation has been recorded at the Belle Fourche Experiment Farm, and the total depth in inches by months from April to September is shown in Table II. The record of evaporation was not kept for the month of March, but at Newell crops ordinarily make little growth during that month and hence this omission is not of importance. The evaporation is determined from a free water surface, the method being that employed at all of the stations where the Biophysical Laboratory of the Bureau of Plant Industry has been cooperating.[7]

TABLE II.—*Monthly evaporation from a free water surface at the Belle Fourche Experiment Farm from April to September of each year, 1908 to 1919, inclusive.*

[Evaporation and precipitation data in inches.]

Year.	Apr.	May.	June.	July.	Aug.	Sept.	Total.	Precipitation.	
								April to September, inclusive.	Ratio to evaporation.
1908	5.535	5.917	6.821	8.081	7.866	6.745	40.965	8.98	1:4.6
1909	3.657	6.413	5.859	7.698	8.243	5.001	36.871	14.37	1:2.6
1910	5.408	5.306	8.975	10.429	7.295	4.302	41.715	9.71	1:4.3
1911	4.649	8.302	10.241	10.714	6.682	6.113	46.701	4.70	1:9.9
1912	4.849	6.423	8.175	7.980	6.604	3.713	37.744	14.36	1:2.6
1913	4.705	4.302	7.046	8.235	8.144	4.707	37.139	8.32	1:4.5
1914	3.369	5.133	6.712	8.737	6.966	4.194	35.111	8.21	1:4.3
1915	4.454	3.970	4.612	5.352	5.113	3.956	27.457	17.08	1:1.6
1916	3.689	5.269	5.138	7.519	5.438	5.429	32.482	10.23	1:3.2
1917	2.018	4.704	6.271	9.536	6.983	5.307	34.819	10.01	1:3.5
1918	3.278	5.171	6.555	6.482	7.129	3.951	32.566	14.65	1:2.2
1919	3.519	6.769	8.904	9.564	8.224	5.122	42.102	8.44	1:5.0
Average	4.094	5.640	7.109	8.361	7.057	4.878	37.139	10.76	1:3.5

The average evaporation for the six months from April to September, inclusive, for the 12 years from 1908 to 1919 was 37.139 inches. The lowest total evaporation, 27.457 inches, was recorded in 1915, the year of the greatest rainfall during the same months. The highest total evaporation, 46.701 inches, was recorded in 1911, the year of the lowest seasonal rainfall. Thus the evaporation usually varies inversely with the precipitation, though this is not always the case.

[7] Briggs, L. J., and Belz, J. O. Dry farming in relation to rainfall and evaporation. U. S. Dept. Agr., Bur. Plant Indus. Bul. 188, p. 16–20. 1911.

The ratio of precipitation to evaporation, also given in Table II, shows the evaporation for the 12 years to be 3.5 times the precipitation. In 1915 the ratio was the narrowest, the evaporation for that year being only 1.6 times the precipitation. In 1911 the ratio was the widest, the evaporation being 9.9 times the precipitation. The ratio of precipitation to evaporation is a fair indication of the seasonal moisture conditions as related to crop yields.

WIND.

The record of wind measurement has been taken at the Belle Fourche Experiment Farm during the growing season since May, 1909. The anemometer stands near the evaporation tank at a height of about 2 feet from the surface of the ground. The average wind velocities in miles per hour during the six months from April to September for the years 1908 to 1919, inclusive, are presented in Table III.

TABLE III.—*Average wind velocity at the Belle Fourche Experiment Farm for the six months from April to September, during the 12-year period from 1908 to 1919, inclusive.*

[Data in miles per hour.]

Month.	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	Average.
April	.....	9.1	9.2	9.2	9.5	6.2	8.2	6.6	7.8	7.8	9.2	7.4	8.2
May	8.3	10.1	8.2	11.6	11.1	5.9	7.7	7.4	8.7	5.7	6.6	7.3	8.2
June	7.2	6.2	9.3	9.1	7.6	6.8	6.7	6.2	7.3	6.3	4.5	7.7	7.1
July	5.0	6.0	7.7	7.9	6.0	5.8	5.0	5.0	5.1	5.3	4.2	6.7	5.8
August	6.8	5.6	6.6	7.3	6.9	5.1	5.0	4.1	4.4	4.2	2.8	5.8	5.4
September	6.5	5.7	6.2	7.9	7.6	4.5	6.2	5.9	6.2	5.1	2.2	5.5	5.8
Average	6.8	7.1	7.9	8.8	8.1	5.7	6.5	5.9	6.6	5.7	4.9	6.7	6.8

The average wind velocity during this period was 6.8 miles per hour. The highest average wind velocity, 8.8 miles per hour, was recorded in 1911, while the lowest, 4.9 miles per hour, was observed in 1918. The velocity during April, May, and June was considerably higher than in July, August, and September. The velocity of the wind has a decided influence upon the crops. The evaporation from the surface of the soil or plant is greatly increased by wind. Hot winds, such as occurred in 1914 and 1917, caused the cereal plants to be prematurely ripened or deadened before the grain was fully developed. Winter wheat was injured somewhat nearly every spring by the blowing of the soil before the spring rains had moistened it. In 1916 some of the spring grains had to be resown because of being blown out after emergence. Owing to the high wind velocity in the early spring, together with the tendency of the soil to blow at that time, it was necessary practically to discontinue summer fallowing as a preparation for grain crops.

TEMPERATURE.

The temperatures at the Belle Fourche Experiment Farm are recorded daily throughout the year by means of maximum and minimum thermometers. During the growing season a thermograph was also used. The mean monthly temperatures in degrees Fahrenheit from 1908 to 1919, inclusive, are shown in Table IV.

TABLE IV.—*Mean monthly temperatures (in degrees F.) at the Belle Fourche Experiment Farm during the 12-year period from 1908 to 1919, inclusive.*

Month.	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	Average.
January	.....	12	18	20	12	13	27	16	5	13	9	29	16
February	.....	23	8	22	24	17	14	19	22	11	20	18	18
March	.....	32	46	39	19	23	33	21	34	25	40	31	31
April	48	38	51	43	47	48	43	52	42	40	41	43	45
May	52	52	52	58	55	53	55	51	52	50	55	56	53
June	63	66	68	73	66	66	65	58	60	62	69	70	66
July	73	70	76	71	70	70	76	64	74	75	69	75	72
August	68	75	68	65	68	74	69	66	67	67	70	71	69
September	64	61	59	59	52	59	62	56	58	60	56	61	59
October	45	46	51	43	45	42	49	50	43	42	50	35	45
November	37	31	31	25	38	37	39	34	32	41	31	23	33
December	22	10	25	20	28	23	15	25	13	13	25	14	19
Average	.....	43	46	45	44	44	46	43	42	42	45	44	44

The average annual mean temperature was 44°. The absolute minimum during this period was −37° F. in January, 1916, and the absolute maximum was 109° F. in July, 1910. The temperature has not been a limiting factor in the yields of most of the spring grains. The grain sorghums and late varieties of proso, however, usually were frosted before fully mature. Winter wheat suffered some injury from low temperatures nearly every year and during the winter of 1917–18 was almost completely destroyed.

TABLE V.—*Dates of killing frosts, the last in spring and the first in autumn, at the Belle Fourche Experiment Farm, for each year from 1908 to 1919, inclusive.*

Year.	Last frost in spring.		First frost in fall.		Frost-free period.	Year.	Last frost in spring.		First frost in fall.		Frost-free period.
	Date.	Temperature.	Date.	Temperature.			Date.	Temperature.	Date.	Temperature.	
		°F.		°F.	Days.			°F.		°F.	Days.
1908	May 20	29	Sept. 26	22	129	1915	May 21	32	Sept. 14	31	115
1909	May 17	26	Sept. 23	31	128	1916	May 16	31	Sept. 14	28	121
1910	May 23	31	Aug. 25	32	93	1917	May 31	30	Oct. 7	20	145
1911	May 11	30	Aug. 27	32	107	1918	May 21	31	Sept. 18	28	120
1912	May 4	32	Sept. 23	32	141	1919	June 1	32	Oct. 9	12	130
1913	May 6	32	Sept. 24	29	140						
1914	May 13	30	Oct. 5	28	144	Average.	May 18	30.5	Sept. 21	28	126

The dates and minimum temperature of the last spring and first autumn frosts each year are shown in Table V. The latest spring

frost was recorded in 1919 on June 1, while the earliest autumn frost was observed in 1910 on August 25. The average frost-free period was 126 days, but this has varied from 93 days in 1910 to 145 days in 1917. The frost-free period is long enough to permit full maturity of all adapted varieties of small grains at Newell.

EXPERIMENTAL METHODS.

PREPARATION OF THE LAND.

Most of the cereals on dry land were sown on either summer fallow or corn ground. Stubble land was usually plowed 6 to 8 inches deep with a disk plow in the fall and left rough over winter. Corn ground was not disturbed until spring, when it usually was double disked and harrowed before seeding. The fall-plowed fallow was not cultivated in the spring until weeds and volunteer grains began to grow, but after this time was kept bare throughout the season by the use of the disk or spring-tooth harrow. Owing to the tendency toward soil blowing early in the spring, which seemed to increase each year after the virgin sod had decayed, it became necessary to conduct most of the experiments on cornland. Yields of grain on summer-fallowed land were more certain and somewhat higher than with other methods of preparation, but were less profitable than on corn ground because of the larger expense for tillage. All of the experiments with winter wheat on the dry land were conducted on fallow.

PLAT EXPERIMENTS.

Nearly all experiments except those in the breeding nurseries and the preliminary varietal experiments were conducted in field plats. These plats in 1908, 1909, and most of them in 1910 were 2 by 8 rods in size, containing one-tenth of an acre. The plats were separated by 5-foot alleys, and the road between each series of plats and the next was either 16.5 or 20 feet wide.

Most of the experiments in 1911 and all of those in 1912 and thereafter were in plats made by sowing a single drill width across an 8-rod series. As the drill was 6 feet wide, this gave a plat of one fifty-fifth of an acre in area. The alleys between these plats have been 19.2 inches in width. By the use of plats and alleys of these dimensions it was possible to sow five plats within the area formerly occupied by a tenth-acre plat. As the plants draw considerable moisture and plant food from the alleys, it has been thought fair to consider these $\frac{1}{55}$-acre plats as fiftieth-acre plats in computing acre yields.

REPLICATION OF PLATS.

In 1908, 1909, and 1910, when the experiments were conducted on tenth-acre plats, there was only a single plat of each variety. Check

plats of standard varieties of each cereal were sown at regular intervals in 1909 and 1910, and in most of the experiments in 1908. As this method did not appear to be entirely satisfactory, a change was made in 1911 in some of the experiments and in all those conducted from 1912 to 1919. The size of the plats was reduced, as stated in the preceding paragraph, and the experiments were replicated. In the varietal experiments, three to five plats of each variety were grown. In rate-of-seeding and date-of-seeding experiments it has been considered sufficient to grow three plats of each rate or date, as there is a correlation between the different parts of the experiment which is not found in the varietal experiments. Some of the date-of-seeding experiments were sown only in duplicate.

RATES AND DATES OF SEEDING.

The usual rates of seeding of the grains in the varietal and date-of-seeding experiments on both dry and irrigated land are shown in Table VI.

TABLE VI.—*Rates of seeding of the grains in varietal and date-of-seeding experiments on dry and on irrigated land on the Belle Fourche Experiment Farm.*

Crop.	Rate of seeding per acre.		Crop.	Rate of seeding per acre.	
	Dry land.	Irrigated land.		Dry land.	Irrigated land.
Winter wheat.....pecks..	3	4	Barley.....pecks..	5	6
Spring wheat.....do....	4	5	Flax.....pounds..	22.5	30
Winter rye.....do....	4	5	Proso.....do....	22.5	30
Oats.....do....	6	10			

Spring grains have been sown as early as seemed practicable. During wet spring weather the seeding has sometimes been considerably delayed. In a few seasons some of the grains have been sown in March, but usually the spring grains were sown between April 1 and May 10. Winter grains were usually sown between September 15 and October 1, which appeared to be the most favorable time for fall sowing.

NURSERY EXPERIMENTS.

NATURE OF THE WORK.

The nursery experiments at Newell have included varieties newly introduced, those of which there was not sufficient seed for sowing in the field plats, and also pure-line selections from the better commercial

varieties. The last has been the most important feature of the nursery work.

The chief objects sought in the pure-line selections were: (1) To obtain high-yielding and drought-resistant strains of wheat, oats, and barley; (2) to obtain a more winter-hardy and high-yielding winter wheat; and (3) to obtain a high-yielding awnless variety of hard red winter wheat.

NURSERY METHODS.

Single heads were selected from the field plats, the aim being to obtain as many types as possible. Each head was described carefully before it was thrashed. The seeds from each head were sown in a 5-foot row, 25 seeds usually being sown in each row. The dates of sowing, emergence, heading, and ripening were recorded, as were such other notes on hardiness, yield, etc., as appeared desirable. Most of the selections were retained and sown in longer rows in the following years. From 1910 to 1915, inclusive, most of the nursery rows were 60 feet long. These rows were sown with the grain drill. Since 1915 most of the nursery experiments were conducted in 16-foot or 17-foot rows, although some of the best strains were tested in 60-foot rows, making possible a more rapid increase of seed. In most cases the nursery experiments were replicated from two to four or occasionally six times, depending on the supply of seed and the area of land available. Yields of grain and straw were recorded, and when the yield of grain was sufficient the weight per bushel also was determined. The better strains and varieties grown in the nursery were later sown in the field plats.

A number of pure-line selections of wheat and oats made at Newell have been tested in field plats for two to seven years.

EXPERIMENTS ON DRY LAND.

EXPERIMENTS WITH WHEAT.

The experiments with wheat at Newell on dry land have included plat and nursery experiments with both spring and winter varieties. These were chiefly varietal, rate-of-seeding, and date-of-seeding experiments, although considerable effort was devoted to the improvement of varieties by selection. Wheat is the most important small-grain crop in the northern Great Plains. Consequently, the experiments with wheat at Newell have been much more extensive than with any other grain.

TABLE VII.—*Yields of the varieties of spring wheat grown on dry land on the Belle Fourche Experiment Farm, 1908 to 1919, inclusive.*

Class, group, and variety.	C. I. No.[a]	Yields per acre (bushels).												Average.		
		1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1908 to 1919	1913 to 1919	1917 to 1919
COMMON.																
Fife:																
Marquis	[b] 3641	....	....	....	....	3.8	16.8	8.0	50.9	8.1	8.3	29.3	6.7	.....	18.3	14.8
Ghirka Spring	1517	16.2	11.7	12.9	0	1.9	16.3	....	40.2	8.9	11.1	....	....	.....	.....	....
Glyndon	2873	....	....	....	....	0	15.8	6.3	39.8	4.1	9.1	....	....	.....	.....	....
Kitchener	4800	....	....	....	....	....	....	....	....	....	....	[c]30.9	8.5	.....	.....	....
Power	[d] 3697	18.5	17.3	10.6	0	0	16.6	5.1	43.4	6.5	10.2	30.0	6.3	13.7	16.9	15.5
Ruby	6047	....	....	....	....	....	....	....	....	....	....	....	6.9	.....	.....	....
Rysting	3022	19.3	15.0	10.3	0	0	15.0	5.1	40.6	4.4	8.8	....	....	.....	.....	....
Bluestem:																
Haynes	2874	....	....	....	....	0	14.2	4.7	42.0	5.6	8.0	26.9	5.0	[e]12.3	15.2	13.3
Do	3020	18.3	13.8	9.0	0	0	14.1	5.1	....	....	....	....	....	.....	.....	....
Do	3021	17.0	....	....	....	....	....	....	....	....	....	....	....	.....	.....	....
Preston:																
Preston	3081	....	....	....	....	0	19.5	7.2	46.9	5.8	8.5	22.7	5.3	.....	16.6	12.2
Do	3087	....	....	....	....	0	19.0	6.6	47.2	....	....	....	....	.....	.....	....
Pioneer	4324	....	....	....	....	....	....	....	45.4	6.2	9.2	24.0	5.2	.....	.....	12.8
Ladoga:																
Changli	2911	....	....	....	....	11.7	14.6	12.2	43.8	8.0	14.4	....	....	.....	.....	....
Huron	4935	....	....	....	....	....	....	....	....	5.2	6.6	32.7	5.0	.....	.....	14.8
Ladoga (Spring Turkey)	4154	....	....	....	....	0	16.2	7.9	32.8	....	....	....	....	.....	.....	....
Laramie	6235	....	....	....	....	....	....	....	....	....	....	....	7.7	.....	.....	....
Manchuria	[f] 2492	16.2	16.0	12.8	0	4.5	17.1	7.8	45.6	12.9	12.2	24.2	6.9	14.7	18.1	14.4
Norka	4377	....	....	....	....	....	....	....	....	....	....	....	7.5	.....	.....	....
Miscellaneous:																
Prelude	4323	....	....	....	....	....	....	....	35.4	8.1	12.6	27.7	3.1	.....	.....	14.5
Regenerated Defiance	3703	....	....	....	....	....	....	6.6	....	....	....	....	....	.....	.....	....
DURUM.																
Kubanka:																
Acme	5284	....	....	....	....	....	....	....	....	....	10.9	35.3	9.7	.....	.....	18.6
Adjini	2941	18.3	....	....	....	....	....	....	....	....	....	....	....	.....	.....	....
Arnautka	1493	22.3	22.6	8.3	0	0	17.1	9.5	54.9	14.8	11.0	34.0	9.4	17.0	21.5	18.1
Do	1537	....	....	11.5	0	0	....	....	....	....	....	....	....	.....	.....	....
Do	1547	21.3	22.0	9.2	0	0	....	....	....	....	....	....	....	.....	.....	....
Do	4064	....	....	....	....	....	....	....	56.2	10.3	13.1	34.2	9.9	.....	.....	19.1
Buford	5295	....	....	....	....	....	....	....	....	....	....	....	8.3	.....	.....	....
Kubanka	1354	24.8	19.5	4.0	0	0	....	....	....	....	....	....	....	.....	.....	....
Do	1440	24.9	21.4	7.4	0	0	15.6	....	54.4	13.8	11.3	34.5	8.7	.....	.....	18.2
Do	1516	23.8	22.6	5.3	0	0	19.1	9.6	54.5	19.7	11.8	34.9	8.9	17.5	22.6	18.5
Do	2246	21.0	....	....	....	....	....	....	....	....	....	....	....	.....	.....	....
Do	2882	23.2	....	....	....	....	....	....	....	....	....	....	....	.....	.....	....
Kubanka No. 8	4063	....	....	....	....	....	....	....	....	11.0	6.6	....	....	.....	.....	....
Kubanka Selection No. 712	1516	....	....	....	....	....	....	....	....	....	[c]12.5	35.8	8.6	.....	.....	19.0
Kubanka Selection No. 715	1516	....	....	....	....	....	....	....	....	....	[c]12.5	33.5	9.0	.....	.....	18.3
Mindum	5296	....	....	....	....	....	....	....	....	....	....	....	9.0	.....	.....	....
Monad	3320	....	....	....	....	....	....	....	....	....	11.6	33.6	9.7	.....	.....	18.3
Pererodka	1350	22.5	23.2	5.2	0	0	16.7	9.8	58.2	13.7	....	....	....	.....	.....	....
Pierson	4163	....	....	....	....	....	....	....	....	....	....	36.3	[c]6.3	.....	.....	....
Yellow Gharnovka	1444	22.7	20.9	5.0	0	0	16.5	7.4	54.0	....	....	....	....	.....	.....	....
Peliss:																
Peliss	1584	21.7	....	....	....	....	....	....	....	....	....	....	....	.....	.....	....
Red Durum:																
D-5	3322	....	....	....	....	....	....	....	....	....	11.8	32.9	8.6	.....	.....	17.8
Selection No. 735	1516	....	....	....	....	....	....	....	....	....	[c]10.4	35.3	8.6	.....	.....	18.1

[a] Cereal Investigations number.
[b] Marquis, C. I. No. 3276, grown 1912 to 1916, inclusive.
[c] One plat only.
[d] Power, C. I. No. 3025, grown 1908 to 1916, inclusive.
[e] Average of Haynes, C. I. No. 3020, from 1908 to 1911, inclusive, and C. I. No. 2874, from 1912 to 1919, inclusive.
[f] Manchuria Selection No. 2492–38, grown in 1918 and 1919.

SPRING WHEAT.

VARIETAL EXPERIMENTS.

The varieties of spring wheat grown in the plat experiments on dry land are mostly those included in two main classes, the durum wheats and the common hard red spring wheats.[8] Other types of spring wheat were poorly adapted and were grown only in nursery rows or in preliminary plat experiments. A total of 44 varieties was grown in plats during the 12-year period. In some cases several lots of wheat under the same name but from different sources or different introductions have been included, so that the actual number of distinct varieties is somewhat less than 44. The annual and average yields for all varieties and strains are shown in Table VII.

FIG. 4.—Heads and glumes of two important varieties of spring wheat grown on the Belle Fourche Experiment Farm: *1*, Marquis common wheat; *2*, Kubanka durum wheat.

As shown in Table VII, good yields of spring wheat were produced in 1908, 1909, 1915, and 1918, fair yields in 1913, poor yields in 1910, 1914, 1916, 1917, and 1919, and failures of practically all varieties in 1911 and 1912. These yields depended largely upon the

[8] For a more complete discussion of the history and growing of these varieties of wheat, see Clark, J. Allen, Martin, John H., and Smith, Ralph W. Varietal experiments with spring wheat on the northern Great Plains. U. S. Dept. Agr. Bul. 878, 47 p., 3 pl., 2 fig. 1920.

amounts and distribution of the seasonal precipitation. The yields of the durum wheats were considerably reduced in 1910, on account of hot winds at flowering time which prevented fertilization. In 1911 the wheat sown in the spring did not emerge until August. The failure in 1912 was caused by a deficient supply of soil moisture in the spring, together with the low precipitation during May and June. In 1916 the wheat was badly injured by rust.

The durum varieties have outyielded the common varieties in nearly all seasons. This was due only in part to the greater resistance of durum wheat to rust and drought, for the durum varieties have given the highest yields in the most favorable seasons. The Kubanka variety, C. I. No. 1516, has the highest average yield during the en-

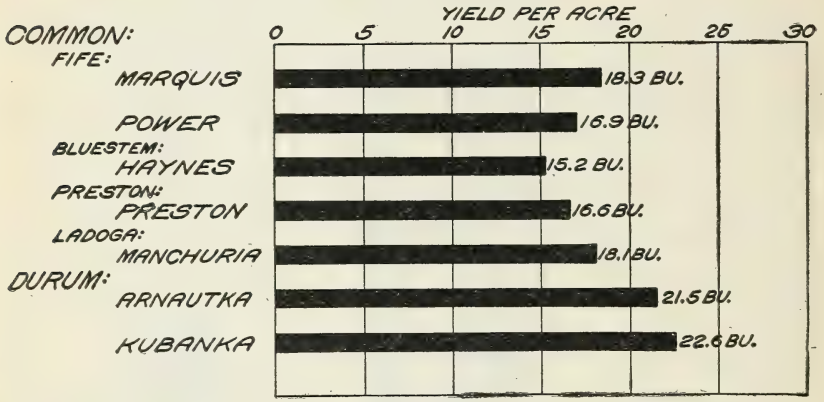

FIG. 5.—Diagram showing the average yields, in bushels per acre, of seven varieties of spring wheat on dry land at the Belle Fourche Experiment Farm during the 7-year period from 1913 to 1919, inclusive.

tire 12 years and also during the 7-year period, 1913 to 1919, inclusive. This variety appears to be slightly more productive than the Kubanka strain, C. I. No. 1440, and is slightly different in appearance. A head of Kubanka wheat is shown in figure 4.

Several other durum wheat varieties yielded about as much as or even more than Kubanka during the three years 1917, 1918, and 1919. These small differences probably are not significant.

Marquis is the highest yielding variety of common wheat. During the period from 1913 to 1919, inclusive, it outyielded all other common-wheat varieties. A head of Marquis wheat is shown in figure 4. Manchuria, the second highest yielding common wheat, is a soft wheat of low milling and baking value. The Power, Haynes, and Preston varieties show average yields since 1913 considerably below that of Marquis. The yields of the leading varieties grown since 1913 are shown graphically in figure 5.

Only five varieties were grown during the entire 12-year period. Of these only two, Arnautka, C. I. No. 1493, and Kubanka, C. I. No. 1516, were grown continuously from the same original strain. In order to have the experiments coordinated with other experiments with wheat in the northern Great Plains, seed of Power and Haynes wheat having different C. I. numbers than those previously grown was used in the later years. In 1918 and 1919 a selection of Manchuria was substituted for the parent variety in the experiments. Table VIII shows the average dates of heading and ripening, the average height, the average percentage of stem-rust infection, the average weight per bushel, and the average yields of grain and straw of the five varieties of spring wheat grown during each of the 12 years from 1908 to 1919, inclusive.

The durum varieties shown have higher yields of grain and straw, a heavier weight per bushel, and a lower stem-rust infection. The Manchuria variety is considerably earlier and the Haynes much later than the other varieties shown.

TABLE VIII.—*Agronomic data for five varieties of spring wheat grown on dry land on the Belle Fourche Experiment Farm, 1908 to 1919, inclusive.*

Group and variety.	C. I. No.	Date of—		Height.[a]	Stem rust.[b]	Weight per bushel.[a]	Yields per acre.	
		Heading.[a]	Maturity.[a]				Grain.	Straw.[a]
				Inches.	*Per cent.*	*Pounds.*	*Bushels.*	*Pounds.*
Fife:								
Power	[c] 3697	July 8 [d]	July 31	28	35.0	57.3	13.7	1,837
Bluestem:								
Haynes	[e] 2874	July 11 [d]	Aug. 2	29	42.5	53.7	12.3	1,815
Ladoga:								
Manchuria	2492	July 1	July 27	31	24.0	56.0	14.7	1,699
Durum:								
Arnautka	1493	July 4	July 30	33	10.5	59.8	17.0	1,877
Kubanka	1516	July 5	...do....	30	7.0	60.3	17.5	1,930

[a] Average for 9 years (1908 to 1910, 1913 to 1917, and 1919).
[b] Average for 2 years (1915 and 1916).
[c] Power, C. I. No. 3025, grown from 1908 to 1916, inclusive.
[d] Date of heading computed in 1914.
[e] Haynes, C. I. No. 3020, grown from 1908 to 1912, inclusive.

RATE-OF-SEEDING EXPERIMENTS.

A rate-of-seeding experiment with Kubanka durum wheat, C. I. No. 1440, was conducted during the 9-year period 1909 to 1917, inclusive. The wheat was not sown in 1911, and the crop failed in 1912 on account of drought. The yields were too low to be of much significance in 1910 and 1914. In 1915 the yields were exceedingly large. The experiment was conducted on single tenth-acre plats in 1909 and 1910, but in triplicate fiftieth-acre plats in all other years.

The rates of seeding ranged by 1-peck intervals from 2 to 8 pecks per acre, but the wheat was not sown at all of these rates during all years of the experiment. The annual and average yields obtained in the rate-of-seeding experiment are shown in Table IX.

TABLE IX.—*Yields of Kubanka durum spring wheat grown in rate-of-seeding experiments on dry land on the Belle Fourche Experiment Farm in 1909, 1910, and 1913 to 1917, inclusive.*

Rate of seeding per acre.	Yields per acre (bushels).								
	1909	1910	1913	1914	1915	1916	1917	Average.	
								1909 to 1917	1913 to 1917
2 pecks	12.5	5.5	.....	.....	.....	.....	.....	.....	.....
3 pecks	.....	.....	9.3	2.2	61.6	11.2	12.4	.....	19.3
4 pecks	14.4	5.5	9.8	2.0	60.1	10.7	12.4	16.4	19.0
5 pecks	16.8	2.8	10.4	2.3	61.4	11.2	11.6	16.6	19.4
6 pecks	17.2	1.8	9.9	2.0	59.2	10.9	12.3	16.2	18.9
7 pecks	.....	.....	10.3	2.0	57.4	11.5	12.4	.....	18.7
8 pecks	17.9	3.4	10.6	1.9	.....	.....	.....	.....	.....

Several interesting facts are brought out by the data shown in Table IX: (1) The net yields were not increased by sowing at a rate in excess of 3 pecks per acre; (2) thin seeding will not materially increase the yields nor prevent failure in dry seasons; and (3) thick seeding reduced the yields only slightly below those of the medium and thin seedings.

It has commonly been assumed that durum wheat should be sown at the rate of 4 to 5 pecks per acre on dry land, as compared with 3 pecks of common wheat, because of the large size of the durum kernels and also because durum wheat tillers less freely than common wheat. Apparently this is offset by other characters of durum wheat, such as the large size of spikes and kernels produced. The above experiment was always conducted on well-prepared land. On a rough seed bed a higher rate of seeding than 3 pecks per acre might be necessary. The slight differences in yield shown above from the different rates of seeding are not significant.

In Table X are shown the average number of days from emergence to maturity, the average height, weight per bushel, and yields of grain and straw of the wheat sown at each rate during the period from 1913 to 1917, inclusive. The average stands recorded during the years 1915 to 1917, inclusive, in thousands of plants per acre, also are shown.

The proportion of straw to grain was slightly higher in the plats sown at the higher rates. The plats sown at 3 pecks per acre matured about one day later than the others. In most years it was observed that the plats sown at the higher rates matured first, but this was not true in all seasons. The wheat from the plats sown at 6 and 7 pecks per acre was an inch shorter than that on the other plats. The weight per bushel of the grain from the thicker sown plats is slightly less than from the plats sown at 3 to 4 pecks per acre.

TABLE X.—*Average agronomic data for Kubanka durum spring wheat grown in rate-of-seeding experiments on dry land on the Belle Fourche Experiment Farm, 1913 to 1917, inclusive.*

Rate of seeding, per acre.	Emergence to maturity.	Height.	Weight per bushel.	Stand per acre.[a]	Yields per acre.	
					Grain.	Straw.
	Days.	*Inches.*	*Pounds.*	*Plants.*	*Pounds.*	*Pounds.*
3 pecks	94	30	58.6	382,000	1,158	2,458
4 pecks	93	30	58.7	428,000	1,140	2,421
5 pecks	93	30	58.3	517,000	1,164	2,649
6 pecks	93	29	58.3	604,000	1,134	2,500
7 pecks	93	29	58.2	678,000	1,122	2,479

[a] Average for 3 years, 1915, 1916, and 1917.

DATE-OF-SEEDING EXPERIMENTS.

A date-of-seeding experiment with Kubanka spring wheat was conducted in 1912, 1915, and 1916. In 1912 the crop was a failure except on the late-sown plats, because of drought during June. In 1915 and 1916 the yields from the early sowing were highest, with the later sowings yielding considerably less. The yield from the earliest sowing in 1916 is not shown, because the wheat was sown on land where soil blowing was unusually severe. The yields from the date-of-seeding experiment are shown in Table XI.

TABLE XI.—*Yields of Kubanka durum spring wheat grown in date-of-seeding experiments on dry land on the Belle Fourche Experiment Farm in 1912, 1915, and 1916.*

Date sown.	Yields per acre (bushels).			
	1912	1915	1916	Average.
April 9 to 25	0	52.5	14.2	22.2
May 1 to 8	0	37.2	12.3	16.5
May 15 to 26	13.5	27.3	4.9	15.2

As shown in Table XI, the early-sown wheat yielded an average of 22.2 bushels per acre, the plats from the second sowing yielded 16.5 bushels, while those sown last yielded only 15.2 bushels per acre. This was in accordance with the usual experience with spring wheat, oats, and barley at Newell, viz, the earlier the sowing the higher the yield.

NURSERY EXPERIMENTS.

Many varieties of spring wheat were grown in rows, but because of their apparent lack of adaptability were not sown in plats. A considerable number of foreign varieties were thus tested in a preliminary way and later discarded. Most of the nursery experiments with spring wheat consisted in the testing of pure-line selections made at Newell from both durum and common spring wheats. Selec-

tions from the Kubanka variety appeared to be most promising. Three of these, designated as Nos. 1440–735, 1516–712, and 1516–715, gave the highest average yields and were grown in plats in the varietal experiments during 1917, 1918, and 1919. The yields in the plat experiments, as shown in Table VII, were not higher than other durum varieties, however, so that nothing of value was obtained from the nursery experiments with spring wheats. A selection of the Manchuria variety, designated as No. 2492–38, proved to be a high-yielding strain in dry seasons. In 1918 and 1919 it was substituted for the parent bulk Manchuria in the varietal experiments in plats. Because this selection is inferior in both yield and quality to several other varieties, it is not considered to be of any particular value.

WINTER WHEAT.

Experiments with winter wheat on dry land have included tests of varieties and selections and of rates and dates of seeding. A large part of the nursery work also was devoted to the improvement of winter wheat by selection. Preliminary experiments showed definitely that the only varieties of winter wheat adapted to the conditions at Newell belonged to the hard red winter or Crimean group. The varieties grown in plats, therefore, consisted almost entirely of wheats of this type.

VARIETAL EXPERIMENTS.

The varietal experiments with winter wheat were begun in the fall of 1907 and continued until 1917. The 1918 crop was completely winterkilled, and no wheat was sown in the fall of 1918. Good yields were obtained in 1908, 1909, 1913, 1914, and 1915. The yields for the latter year were extremely large. The yields in 1910 and 1917 were reduced by drought and in 1916 by winterkilling, rust, and drought. The crop of 1911 was completely killed by drought, and the wheat sown in the fall of 1911 did not emerge until late the following spring, so that no crop was obtained in 1912. The wheat was sown on summer-fallowed land each year and since 1912 has been grown in plats replicated three or five times. The yields are shown in Table XII.

The varieties grown are all of the Crimean group except Alton (Ghirka Winter), an awnless hard red winter variety, and Fultz, a soft red winter wheat. Some differences in yields were obtained from several lots of the Crimean wheats, but it is not certain that these differences are significant. The five varieties which were grown each year from 1910 to 1917, inclusive, gave exactly the same average yield, 21.5 bushels per acre.

TABLE XII.—*Yields of the winter-wheat varieties grown on dry land, on the Belle Fourche Experiment Farm, 1908 to 1917, inclusive.*

Group and variety	C. I. No.	Yields per acre (bushels).										Average.	
		1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1908–1917	1910–1917
Crimean:													
Alberta Red	2979	.....	.....	16.7	0	0	35.0	.....	64.2	11.6	.....	.....	.....
Beloglina	1667	.....	.....	19.2	0	0	37.2	29.9	63.8	11.7	10.3	.....	21.5
Do	2239	.....	.....	19.2	0	0	39.4	29.3	59.4	7.8	.....	.....	.....
Crimean	1435	18.7	31.5	19.7	.....	.....	.....	.....	.....	.....	.....	.....	.....
Do	1437	25.3	36.0	20.3	0	0	36.4	.....	.....	.....	.....	.....	.....
Kharkof	1442	25.4	40.3	22.7	0	0	38.6	28.7	63.8	14.2	4.7	23.8	21.5
Do	1583	22.5	39.0	23.6	0	0	38.8	29.1	62.6	13.2	4.7	23.3	21.5
Do	2208	.....	.....	17.5	.....	.....	.....	.....	.....	.....	.....	.....	.....
Do	4207	.....	.....	.....	.....	.....	.....	.....	.....	9.8	.....	.....	.....
Theiss	1561	.....	.....	19.4	0	0	36.8	31.6	66.3	12.3	6.4	.....	21.5
Turkey	1558	24.1	41.0	17.8	0	0	38.1	.....	65.0	10.3	5.1	.....	.....
Do	1571	25.5	39.0	20.3	0	0	38.7	29.6	65.0	12.3	6.0	23.5	21.5
Do	2943	.....	.....	15.0	0	0	39.3	.....	60.1	9.1	.....	.....	.....
Do	2998	.....	.....	14.2	.....	.....	.....	.....	.....	.....	.....	.....	.....
Do	3055	22.3	44.5	(a)	0	0	35.0	29.6	64.1	9.6	7.9	21.2	.....
Alton:													
Alton	1438	.....	.....	.....	.....	.....	.....	.....	53.7	11.1	6.5	.....	.....
Soft winter:													
Fultz	.....	.....	.....	.....	.....	.....	.....	.....	37.2	.....	.....	.....	.....

[a] Did not emerge.

In Table XIII are shown the average dates of heading and maturity, weight per bushel, and yields of grain and straw of two strains of Kharkof and one of Turkey wheat grown on the Belle Fourche Experiment Farm from 1908 to 1917, inclusive. The yields also are shown graphically in figure 6. It is seen that the dates of heading

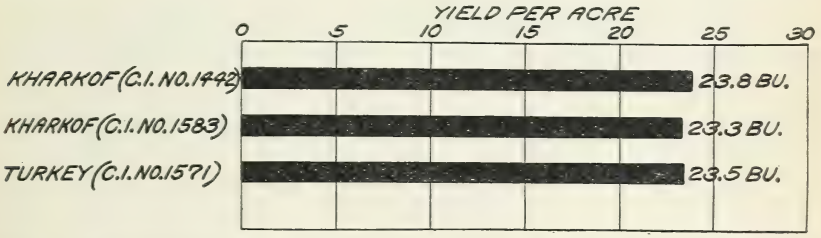

FIG. 6.—Diagram showing the average yields, in bushels per acre, of the leading varieties of winter wheat on dry land at the Belle Fourche Experiment Farm for the 12-year period from 1908 to 1919, inclusive.

and maturity and the height are the same for all three wheats and that the differences in weight per bushel and yield are too small to be significant. From the results obtained it is concluded that the bulk unselected varieties, Turkey and Kharkof, are identical in all the above characters, including yield. These varieties, however, have outyielded all others grown in the plat and nursery experiments.

TABLE XIII.—*Average agronomic data for three varieties of winter wheat grown on dry land on the Belle Fourche Experiment Farm, 1908 to 1917, inclusive.*

Variety.	C. I. No.	Date of —		Height.[b]	Weight per bushel.	Yields per acre.[c]	
		Heading.[a]	Maturity.[a]			Grain.	Straw.
				Inches.	*Pounds.*	*Bushels.*	*Pounds.*
Kharkof	1442	June 29	July 25	33	59.5	23.8	2,319
Do	1583	do	do	33	59.1	23.3	2,340
Turkey	1571	do	do	33	59.3	23.5	2,347

[a] Average for 6 years, 1910 and 1913 to 1917, inclusive.
[b] Average for 8 years, 1908 to 1910 and 1913 to 1917, inclusive.
[c] Average for 10 years, 1908 to 1917, inclusive.

EXPERIMENTS WITH WINTER-WHEAT SELECTIONS.

About 600 selected heads of Turkey, Kharkof, and Crimean wheats were sown in head rows in the fall of 1908. Practically all of these were sown in 60-foot rows the following year and many of them for several years following. The selections giving the highest yields in the nursery were later grown in plats. About 35 of these selections were sown in plats in the fall of 1910, but they failed on account of drought. A few selections were again sown in plats in the fall of 1912 and these produced a crop in 1913.

Several additional selections which had shown high yields in the nursery experiments were sown in plats in the fall of 1914. The better strains were continued in the plats in 1916 and a few in 1917. The 1918 crop was entirely winterkilled. The yields are shown in Table XIV.

TABLE XIV.—*Yields of the winter-wheat selections compared with the unselected parent varieties grown on dry land on the Belle Fourche Experiment Farm, 1913 to 1917, inclusive.*

Group and variety	C. I. No.	Yields per acre (bushels).					
		1913	1914	1915	1916	1917	Average.
Crimean:							
Kharkof	1442	.....	28.7	53.0	13.4	4.7	.....
Do	4207	17.9	28.6	51.6	.....	.....	.....
Turkey	3055	20.7	29.6	53.3	12.4	7.9	24.8
Turkey selection 159	.....	24.2	27.1	55.4	15.3	8.9	26.1
Turkey selection 173	.....	.....	.....	57.7	14.1	.....	.....
Turkey selection 209	.....	.....	.....	42.7	.....	.....	.....
Turkey selection 285	.....	.....	.....	47.0	12.3	.....	.....
Turkey selection 296	.....	21.4	27.3	52.0	13.3	7.3	24.2
Crimean selection 378	.....	17.7	26.2	47.0	13.3	.....	.....
Crimean selection 379	.....	16.9	.....	.....	.....	.....	.....
Alton (awnless):							
Alton selection 343	5298	.....	30.8	46.6	11.9	7.1	.....
Alton selection 350	.....	.....	.....	43.9	9.1	.....	.....
Alton selection 352	5299	15.6	31.2	49.8	12.1	6.8	23.1
Newton (Alton selection 367)	5300	16.9	31.8	49.4	10.5	4.8	22.7

Four selections were grown during each of the five years, and seven others were grown from one to four years each. Turkey, C. I. No.

3055, was grown each year, and Kharkof, C. I. No. 1442, was grown from 1914 to 1917, inclusive, for comparison. Four of these selections are awnless, very similar to Alton (Ghirka Winter) wheat. They, however, are more vigorous and have larger kernels than Alton. The grain is very similar to that of Turkey and probably equal to that variety in quality.

Selection No. 159 produced the highest average yield, 26.1 bushels per acre, which was 1.3 bushels more than the parent strain, C. I. No. 3055. This selection was one of the highest yielders in the nursery experiments, and it also outyielded all varieties and selections in the experiments under irrigation. Of the 600 original selections this is the only one which has shown a marked increase over the parent varieties.

The awnless strains yielded less than Turkey or Kharkof and most of the awned selections. The highest yielding awnless selection, C. I. No. 5299, has an average yield of 1.7 bushels per acre less than Turkey, but it yielded slightly more than the Turkey variety in 1914. The better awnless selections have been fully as hardy and nearly as resistant to drought as the Turkey variety. Because of the lower yields of the awnless strains none of them was distributed.

RATE-OF-SEEDING EXPERIMENTS.

Experiments to determine the best rate to sow Kharkof winter wheat were attempted from 1910 to 1918, inclusive. The 1910 crop failed to germinate, and the 1912 crop did not emerge until late in the spring following the seeding and was plowed up. The 1911 crop was killed by spring and summer drought and the 1917 and 1918 crops were destroyed by a combination of winterkilling and soil blowing. Results from the rate-of-seeding experiment were thus obtained only during the period from 1913 to 1916, inclusive. Good crops were obtained except in 1916, when winterkilling and soil blowing injured the crop, in addition to severe damage from stem rust. The rates of seeding here recorded ranged from 2 to 7 pecks per acre. The yields are shown in Table XV.

TABLE XV.—*Yields of Kharkof winter wheat grown in rate-of-seeding experiments on dry land on the Belle Fourche Experiment Farm, 1913 to 1916, inclusive.*

Rate of seeding, per acre.	Yields per acre (bushels).				
	1913	1914	1915	1916	Average.
2 pecks	26.4	23.0	36.7	3.1	22.3
3 pecks	28.0	26.6	42.6	4.0	25.3
4 pecks	27.3	24.9	48.3	4.6	26.2
5 pecks	26.8	27.4	43.6	5.1	25.7
6 pecks	27.4	24.6	45.8	5.4	25.8
7 pecks	28.2	27.8	44.0	6.3	26.5

The yields from all rates of seeding from 3 to 7 pecks per acre are nearly the same. The yields from the 2-peck seedings, however, have been the lowest each year. In 1913, 1914, and 1916, the 7-peck seeding gave the highest yield, while in 1915 the highest yield per acre was obtained from the 4-peck seeding. The 7-peck seeding gave the highest average yield per acre during the 4-year period, but the largest net yield was obtained from seeding at the rate of 4 pecks per acre. Sufficient data have not been obtained to draw definite conclusions, but apparently 4 pecks per acre is the most profitable rate of seeding.

DATE-OF-SEEDING EXPERIMENTS.

A date-of-seeding experiment with Turkey winter wheat was conducted each year from 1908 to 1918, inclusive. Drought destroyed the crops of 1911 and 1912, and the wheat was almost entirely destroyed by winterkilling and soil blowing in 1916, 1917, and 1918. Some injury from soil blowing resulted in most other years of the experiment. The soil blowing usually occurred in early spring before the rains had begun and before the wheat had made much, if any, growth. The yields from the date-of-seeding experiment with winter wheat during the years in which yields were obtained are shown in Table XVI.

TABLE XVI.—*Yields of Turkey winter wheat grown in date-of-seeding experiments on dry land on the Belle Fourche Experiment Farm, 1908 to 1910 and 1913 to 1915, inclusive.*

Date of seeding.	Yields per acre (bushels).						
	1908	1909	1910	1913	1914	1915	Average.[a]
August 1	.....	.....	.....	29.2	.....	.....	.....
August 16	.....	37.5	19.3	28.1	.....	.....	.....
September 1	23.0	39.0	8.3	28.1	.....	.....	.....
September 16	20.3	40.5	22.0	[b]28.1	[c]20.2	61.6	34.1
October 1	24.3	43.0	([d])	28.1	21.1	60.9	35.5
October 16	24.7	42.0	13.3	21.4	20.7	56.5	33.1
November 1	25.5	37.3	13.2	16.3	19.1	55.2	30.7
November 16	.....	.....	.....	16.1	.....	51.9	.....

[a] Yields for 1910 omitted because of irregularities.
[b] Not sown, yield assumed from earlier and later sowings.
[c] Sown September 20.
[d] Did not germinate.

In 1908 the latest date of seeding, November 1, produced the highest yield. In 1909 the October 1 seeding yielded the highest. The results in 1910 were very irregular, owing to poor germination and soil blowing on some of the plats. In 1913 the August 1 seeding gave the highest yield. A seeding was not made the previous fall on September 16, but as the yields from the seedings of August 16, September 1, and October 1 were all 28.1 bushels, the yield for this date was assumed to be the same, in order to determine the average

yield for five years. The October 1 seeding gave the highest yield in 1914 and the September 16 seeding in 1915.

In the column of Table XVI showing the average yields, the results for 1910 are omitted because of the large irregularities previously mentioned. The highest average yield per acre was obtained from the October 1 seeding and the next highest from the September 16 seeding. With the exception of 1908, seeding later than October 1 resulted in decreased yields each year.

Only limited data are available, but apparently there is no advantage in seeding wheat earlier than September 16 at Newell. In 1916 and 1917 the wheat in the date-of-seeding experiment was so badly injured by soil blowing and winterkilling that it was disked up. It was observed, however, that the plats sown late showed the highest winter survival, the earliest sown wheat having the lowest survival. In both of these years the wheat in the November 1 seeding did not emerge and apparently had not begun to germinate until spring. The wheat in these late-sown plats showed a much better stand in the spring than that in the earlier seedings where the plants had emerged in the fall. In the fall of 1914 the wheat in the November 1 seeding started to germinate, but the plants did not emerge until about April 15 the following spring. The wheat sown November 16 did not even start germination in the fall but it emerged about April 17. The average yield from the three plats sown November 16 was 51.9 bushels per acre.

Winterkilling at Newell is not due to heaving of the plants, but apparently is a result of low temperature, drying out of the soil, and mechanical injury from soil particles blown by the wind. The surviving wheat plants die down to the crown and make no growth during the winter period of nearly five months. It was observed in these experiments that wheat plants which had reached the 2-leaf stage survived the winter as well as or better than plants which had formed several tillers.

NURSERY EXPERIMENTS.

A large part of the nursery work with winter wheat consisted of the testing of the several hundred selections from the Turkey, Kharkof, and Crimean varieties previously mentioned. In 1915, 1916, and 1917 several hundred additional selections of Kharkof were made. Most of these were subsequently destroyed by winterkilling and soil blowing during the three rather severe winters of 1915–16, 1916–17, and 1917–18.

Some hybrids made between awned and awnless types also were destroyed during this time. A large number of winter-wheat varieties were grown in the nursery in 1909 and 1910 and a number each year since then. None of these except the hard red winter varieties

of the Crimean group have given satisfactory yields. The Alton (Ghirka Winter) and Buffum No. 17 varieties were somewhat promising, but were inferior to Turkey in both yield and quality.

COMPARISON OF SPRING AND WINTER WHEATS.

A comparison of the annual and average yields of Kharkof winter wheat with Kubanka durum and Power common spring wheats is shown in Table XVII. The average yields also are shown graphically in figure 7. No winter wheat was sown in the cereal experiments in the fall of 1918, so the yield of winter wheat shown was obtained from a plat of the Turkey variety on fallowed land in the experiments of the Office of Dry-Land Agriculture. The Kubanka and Power varieties were grown in the spring-wheat varietal experiments each year. Kubanka spring wheat, C. I. No. 1440, was sown in the same series with the winter wheat varieties from 1913 to 1917, in-

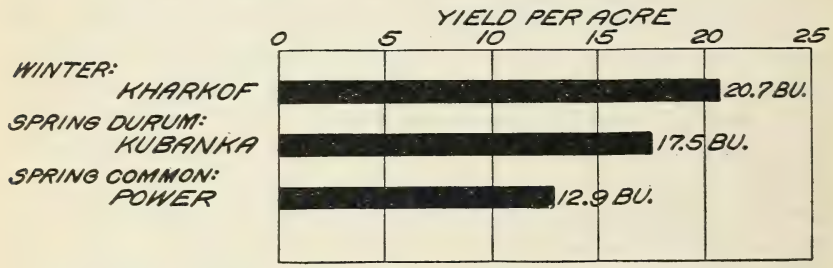

FIG. 7.—Diagram showing the average yields, in bushels per acre, of the best varieties of winter wheat and of durum and common spring wheat on dry land at the Belle Fourche Experiment Farm for the 12-year period from 1908 to 1919, inclusive.

clusive. The average yield during this 5-year period was the same as for Kubanka, C. I. No. 1516, in the spring-wheat varietal experiment, so the yields of the latter are shown here. In 1914 the spring wheat was sown on corn ground instead of fallowed land, so the yields are not entirely comparable with those of winter wheat, which was grown on fallow every year. Plats of Kharkof winter wheat, Kubanka spring wheat, and Swedish winter rye are shown in figure 8.

The crops of both winter and spring wheat in 1911 and 1912 were destroyed by drought. The 1918 crop of winter wheat was destroyed by fall drought, winterkilling, and soil blowing.

Kharkof winter wheat has outyielded Kubanka durum, the highest yielding variety of spring wheat, in 7 out of 10 years in which a crop was obtained. The average yield of Kharkof is 20.7 bushels per acre, compared with 17.5 bushels of Kubanka and 12.9 bushels of Power. The crops of winter wheat in 1916, 1917, and 1918 were damaged by soil blowing and winterkilling, so that spring wheat was more successful during this period. The Kharkof variety was injured by rust in 1916 more than Kubanka, which is rather resistant.

TABLE XVII.—*Yields of the better varieties of winter wheat and of durum and common spring wheats grown on dry land on the Belle Fourche Experiment Farm, 1908 to 1919, inclusive.*

Group and variety.	C. I. No.	Yields per acre (bushels).												
		1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	Average.
Winter:														
Kharkof..	1442	25.4	40.3	22.7	0	0	38.6	28.7	63.8	14.2	4.7	0	[a]10.0	20.7
Spring durum:														
Kubanka.	1516	23.8	22.6	5.3	0	0	19.1	9.6	54.5	19.7	11.8	34.8	8.9	17.5
Spring common:														
Power....	[b]3025	18.5	17.3	10.6	0	0	16.6	5.1	43.4	6.5	10.2	30.0	6.3	12.9

[a] Not grown, yield from a single plat on summer fallow in experiments of the Office of Dry-Land Agriculture.
[b] Power, C. I. No. 3697, grown from 1916 to 1919, inclusive.

Winter wheat, although giving higher average yields, is somewhat less certain than spring wheat in the vicinity of Newell, owing to poor germination of seed during cold fall weather, greater injury

FIG. 8.—Plats on dry land at the Belle Fourche Experiment Farm in 1917: *1*, Kubanka spring wheat; *2*, Swedish winter rye; *3*, Kharkof winter wheat. Note the differences in stand and growth between the winter rye and the winter wheat due to the greater hardiness of the rye.

from soil blowing, and the possibility of winterkilling. In case of failure of winter wheat from these causes, however, there is still an opportunity to sow spring wheat or some other spring crop.

EXPERIMENTS WITH OATS.

Oats is perhaps the most successful feed crop of all the small grains in this region. The yields of oats on the Belle Fourche Experiment Farm, however, usually have been less in pounds per acre than the yields of wheat. Oats are most profitably grown when sown on corn ground early in the spring. If drought or hot winds prevent the oats from filling, the crop can be cut for hay.

VARIETAL EXPERIMENTS.

During the 12-year period from 1908 to 1919, inclusive, 19 varieties and strains of spring oats have been grown in plats. It was soon found that only the early varieties were well adapted to the region, but a few midseason and late varieties were continued in the experiments for comparison. Only three varieties of oats were grown during all of the 12 years. Several early varieties and strains were added to the experiment in 1910, 1912, and 1916. The annual and average yields of the oat varieties are shown in Table XVIII.

TABLE XVIII.—*Yields of oat varieties grown on dry land on the Belle Fourche Experiment Farm, 1908 to 1919, inclusive.*

Group and variety	C. I. No.	Yields per acre (bushels).												Average.		
		1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1908 to 1919	1912 to 1919	1916 to 1919
Early yellow:[a]																
Kherson	459	47.5	25.7	15.0	0	6.2	21.9	13.8	110.8	40.8	33.8	37.8	4.4	29.7	33.7	29.2
Sixty-Day	165	46.6	25.0	15.6	0	6.6	22.7	....	113.7	37.4	34.1	39.8	5.5	....	....	29.2
Sixty-Day selection	625	....	....	14.4	0	7.9	21.6	13.4	107.2	....	....	....	....	....	....	....
Do	626	....	....	16.6	0	9.9	24.6	14.2	117.1	43.4	35.9	39.8	4.2	....	36.1	30.8
Do	165–566	....	....	....	....	7.1	23.3	12.2	106.7	41.8	33.8	34.9	4.0	....	33.0	28.6
Do	165–562	....	....	....	....	6.2	....	....	....	....	....	....	....	....	....	....
Albion (Iowa No. 103)	729	....	....	....	....	....	....	....	....	35.6	30.6	40.6	3.9	....	....	27.7
Richland (Iowa No. 105)	787	....	....	....	....	....	....	....	....	33.5	30.6	39.3	5.0	....	....	27.1
Seventy-five Day	337	....	....	....	....	7.5	21.0	12.8	102.5	....	....	....	....	....	....	....
Nebraska No. 21	841	....	....	....	....	....	....	....	....	....	....	....	4.4	....	....	....
Early Red:																
Burt	293	....	....	....	....	6.0	22.4	16.0	108.0	38.0	37.4	36.4	5.7	....	33.7	29.4
Midseason white:																
Big Four	658	....	32.0	3.6	0	14.1	19.5	0	....	....	....	....	....	....	....	....
Canadian	444	38.8	21.3	4.4	0	10.4	18.5	0	92.9	....	....	....	....	....	....	....
Danish	441	36.1	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Great Dane	....	....	26.6	....	....	....	....	....	....	....	....	....	....	....	....	....
Swedish Select	134	38.1	28.4	2.3	0	9.2	15.2	0	113.7	33.0	19.7	34.6	2.3	24.7	28.5	22.4
Late white (side):																
Yellow Giant	342	19.4	17.5	0	0	....	....	....	....	....	....	....	....	....	....	....
White Russian	551	30.9	20.0	0	0	22.7	14.3	0	106.1	26.8	6.4	46.6	1.7	23.0	28.1	20.4
White Tartarian	300	30.9	22.8	0	0	....	....	....	....	....	....	....	....	....	....	....

[a] The Sixty-Day selections, and also Albion and Nebraska No. 21, which are selections from Kherson, have white kernels, while the parent varieties usually have yellow kernels.

Table XVIII shows that good yields of oats were obtained from all early varieties in 1908, 1915, 1916, 1917, and 1918. Fair yields were grown in 1909 and 1913, and poor yields or failures in the other years. In 1909, 1912, and 1918, the midseason and late varieties were somewhat favored by ample moisture late in the season. In years such as 1910, 1914, 1917, and 1919, when the season was very dry, the early varieties yielded better than the later ones. The Kherson variety, C. I. No. 459, gave the highest average yield, 29.7 bushels per acre, during the 12-year period. A panicle and spikelets of Kherson oats are shown in figure 9. The Swedish Select and

White Russian, both later varieties, yielded considerably less. The Sixty-Day selection, C. I. No. 626, has given the highest yields of any of the varieties since it has been included in the experiments. During the eight years from 1912 to 1919, this variety averaged 2.4 bushels per acre more than Kherson. This variety has a white hull, but usually has a low weight per bushel.

The Sixty-Day variety, C. I. No. 165, has been grown in all years except 1914. During this period it has averaged nearly the same as Kherson, with which it is practically identical. The Burt variety, C. I. No. 293, has been continued in the experiments since 1912. The average of Burt was the same as for Kherson. The Burt variety as grown is a mixture of various colors of kernels.

The Sixty-Day selection, No. 165–566, has yielded slightly less than Kherson or the parent variety, Sixty-Day. It has a white kernel of good quality, however. The Richland and Albion varieties have been included in the experiments since 1916, but have not yielded as high as the other early varieties.

Table XIX shows the average data recorded on the dates of heading and maturity, the height, weight per bushel, and the yields of grain and straw for the three varieties of oats which were grown during the entire 12-year period. The average yields of these three varieties are shown graphically in figure 10. The yield differences are largely due to the greater earliness and shorter straw of Kherson. This variety has an average

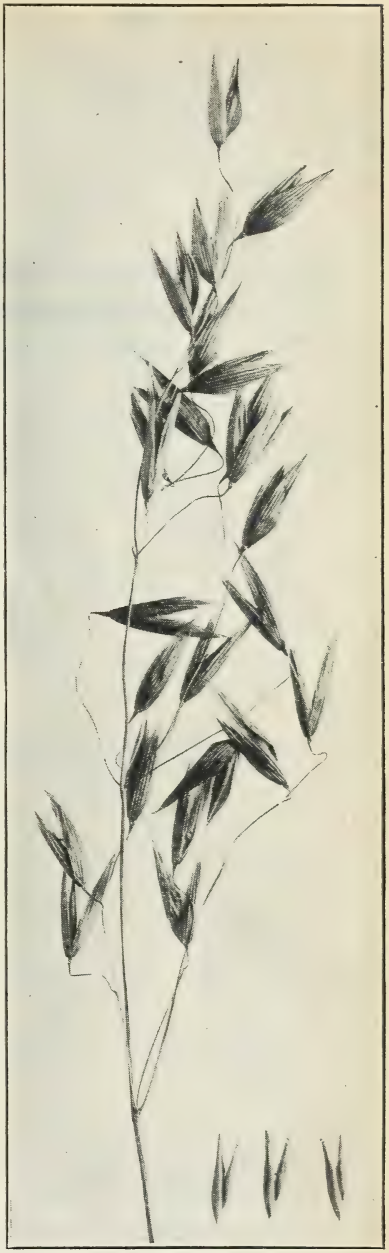

FIG. 9.—Panicle and spikelets of the Kherson oat, the leading dry-land variety at the Belle Fourche Experiment Farm.

maturity 11 days earlier than Swedish Select and 18 days earlier than White Russian. The average height of Kherson was 4 inches less than that of the other two varieties listed. The proportion of grain to straw also is much higher in the Kherson than in the other varieties. The Sixty-Day and other early varieties have given about the same data in the experiments as are shown for Kherson.

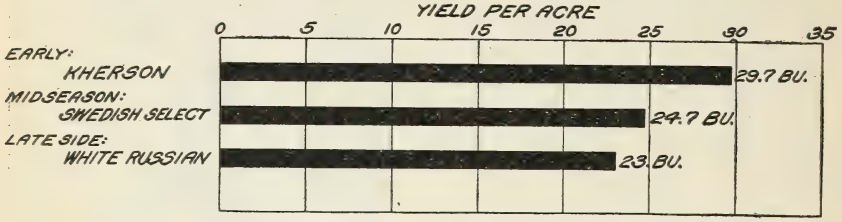

FIG. 10.—Diagram showing the average yields, in bushels per acre, of three varieties of oats on dry land at the Belle Fourche Experiment Farm for the 12-year period from 1908 to 1919, inclusive.

In 1907, two plats of Boswell Winter oats, C. I. No. 480, were sown. Only a small percentage of the plants survived the winter, but these tillered so freely that a yield of 28.5 bushels per acre was obtained. This variety was again sown in 1908 and 1909, but winter-killed entirely each year. Winter oats are not sufficiently hardy for western South Dakota.

TABLE XIX.—*Average agronomic data for three varieties of oats grown on dry land on the Belle Fourche Experiment Farm, 1908 to 1919, inclusive.*

Variety.	C. I. No.	Date of—		Height.[a]	Weight per bushel.[a]	Yields per acre.	
		Heading.[a]	Ripening.[a]			Grain.[b]	Straw.[c]
				Inches.	*Pounds.*	*Bushels.*	*Pounds.*
Kherson	459	July 2	July 23	24	30.4	29.7	1,131
Swedish Select	134	July 11	Aug. 3	28	29.8	24.7	1,330
White Russian	551	July 19	Aug. 10	28	31.3	23.0	1,492

[a] Average for 9 years (1908 to 1910, 1912, 1913, 1915 to 1917, and 1919).
[b] Average for 12 years, 1908 to 1919, inclusive.
[c] Average for 10 years, 1908 to 1913, 1915 to 1917, and 1919.

NURSERY EXPERIMENTS.

The growing of head selections of oats was begun on the Belle Fourche Experiment Farm in 1908, from selections made at the Highmore (S. Dak.) substation in 1907. Other selections were added later, so that a considerable number have been tested. The two most promising selections made at Highmore were included in the plat experiments at Newell in 1912, one of which, No. 165–566, has been continued in the plats each year. As the average yield of this strain is slightly less than that of the parent variety, it is apparent that nothing was accomplished in the improvement of oats by selection.

Many varieties also were grown in nursery rows. Of these, an unnamed variety, designated as C. I. No. 357, outyielded all other varieties and strains during a period of several years. This variety was being increased for plat experiments in 1918, but was never grown in plats at Newell.

RATE-OF-SEEDING EXPERIMENTS.

A rate-of-seeding experiment with oats was conducted on dry land during six seasons. Good yields were obtained in all years except 1910 and 1912. These rates of seeding varied by 2-peck intervals from 2 to 12 pecks per acre, but only four different rates were sown during all of the years. The varieties used in the experiment were Kherson, C. I. No. 459, in 1909 and 1910; Sixty-Day, C. I. No. 165, in 1912 and 1913; and Sixty-Day selection, No. 165–566, in 1915 and 1916. As these varieties are of very similar character, the data are practically as uniform as if the same variety had been grown throughout the entire experiment. The yields are shown in Table XX.

The highest average yields were obtained from sowing the oats at the rate of 6 pecks per acre, with a gradual decrease if sown at higher or lower rates of seeding. The results were so strikingly in favor of the 6-peck rate that the experiment was discontinued in 1916.

TABLE XX.—*Yields obtained in rate-of-seeding experiments with oat varieties*[a] *on dry land on the Belle Fourche Experiment Farm, 1909 to 1916, inclusive.*

Rate of seeding per acre.	Yields per acre (bushels).						
	1909	1910	1912	1913	1915	1916	Average.
2 pecks	25.9						
4 pecks	30.2	11.9	8.9	28.2	120.0	40.0	39.8
6 pecks	32.8	12.5	10.3	27.3	118.2	42.5	40.6
8 pecks	35.3	10.3	9.2	27.3	104.8	40.6	37.9
10 pecks	35.9	4.1	9.7	28.1	109.6	36.1	37.2
12 pecks		3.4	9.1	28.2			

[a] Kherson, C. I. No. 459, grown in 1909 and 1910; Sixty-Day, C. I. No. 165, in 1912 and 1913; and Sixty-Day selection, 165–566, in 1915 and 1916.

Table XXI shows the average number of days from emergence to maturity, the height, weight per bushel, stand of plants per acre, and yields in pounds per acre of grain and straw of the oats in the rate-of-seeding experiments. The data are shown for only four rates of seeding, viz, 4, 6, 8, and 10 pecks per acre. The period of maturity and the height of the plants decrease with the increase in the rate of seeding. The weights per bushel are slightly higher from the heavier rates of seeding. The number of plants per acre is not quite proportional to the rate of seeding. This is due largely to the error in counting the plants in the thicker seedings where the

plants are too close together to be separated. There is also some apparent crowding out of weak plants. The number of plants counted per peck of seed sown ranged from 80,500 in the 10-peck seeding to 98,500 in the 4-peck seeding. The ratio of grain to straw was almost 1 to 1 except in the 8-peck seeding.

TABLE XXI.—*Average agronomic data for oats grown in the rate-of-seeding experiments on dry land on the Belle Fourche Experiment Farm in 1909, 1910, 1912, 1913, 1915, and 1916.*

Rate of seeding per acre.	Emergence to maturity.	Height.	Weight per bushel.[a]	Stand per acre.[b]	Yields per acre.	
					Grain.	Straw.
	Days.	*Inches.*	*Pounds.*	*Plants.*	*Pounds.*	*Pounds.*
4 pecks	83	26	31.2	394,000	1,273	1,275
6 pecks	82	26	32.1	525,000	1,298	1,315
8 pecks	81	25	32.7	672,000	1,213	1,319
10 pecks	80	23	32.8	805,000	1,190	1,213

[a] Average for 4 years, 1909, 1913, 1915, and 1916. [b] Average for 3 years, 1909, 1915, and 1916.

EXPERIMENTS WITH BARLEY.

The yields of the best varieties of barley in pounds per acre on the Belle Fourche Experiment Farm have been nearly as large as those of oats and spring wheat. Most varieties of barley mature more quickly than oats or wheat, and the crop can thus be sown at a later

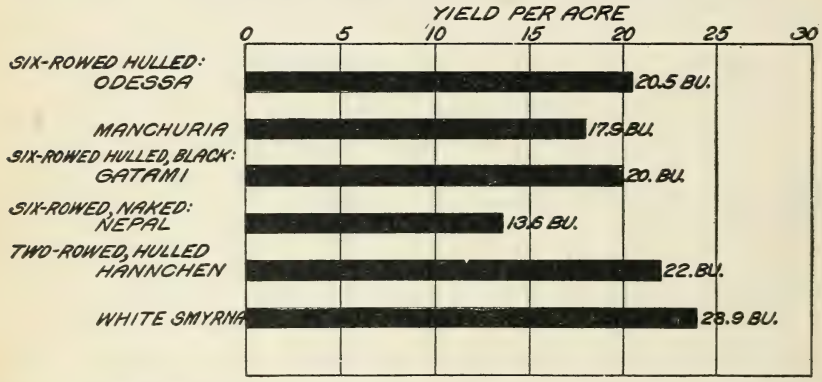

FIG. 11.—Diagram showing the average yields, in bushels per acre, of the leading varieties of barley on dry land at the Belle Fourche Experiment Farm for the 8-year period from 1912 to 1919, inclusive.

date. Barley grown on the dry lands of western South Dakota is used almost exclusively as a feed crop and its market value is of minor importance there.

Winter barley has been sown several years, but has never survived the winter at Newell.

VARIETAL EXPERIMENTS.

Since 1908 25 varieties and strains of barley have been grown in the varietal experiments. Only 1 variety has been grown during the entire period, but 4 varieties were grown continuously from 1909 to 1919, inclusive. The yields are shown in Table XXII. The average yields of 6 varieties of barley are also shown graphically in figure 11.

In Table XXII it can be seen that high yields of barley were obtained in 1915, and fair yields in 1908, 1909, 1916, 1917, and 1918. During the other seasons the yields either were small or else almost complete failures. These differences were chiefly influenced by the seasonal precipitation.

In general the 2-rowed varieties have produced the highest yields. Of the two leading 2-rowed varieties, White Smyrna has given the highest average yield. Because of its earliness this variety has yielded well in dry seasons, but the Hannchen variety yielded best in favorable seasons. Heads of Hannchen and White Smyrna barley are shown in figure 12. The Odessa is the highest yielding 6-rowed

FIG. 12.—Heads of the two leading varieties of barley grown on dry land on the Belle Fourche Experiment Farm: *1*, Hannchen; *2*, White Smyrna.

variety which has been grown for a long period, but the Coast variety has a higher average yield during the years it has been grown. The Gatami variety yields well in dry seasons, but not especially well in favorable seasons. It has further objections in having black glumes and a very brittle peduncle. The Manchuria, which is the leading variety of barley in North Dakota, South Dakota, Minnesota and Wisconsin, has not yielded well at Newell. Three strains of this variety have been grown.

TABLE XXII.—*Yields of varieties of barley grown on dry land on the Belle Fourche Experiment Farm, 1908 to 1919, inclusive.*

Group and variety.	C. I. No.	Yields per acre (bushels).												Average.		
		1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1909 to 1919	1912 to 1919	1915 to 1919
Six-rowed, hulled:																
Coast	690	....	....	....	....	....	....	....	82.8	18.3	22.1	18.4	9.8	....	....	30.3
Odessa	182	....	22.1	8.1	0	9.8	8.7	3.5	69.4	26.1	18.3	20.0	8.0	17.6	20.5	28.8
Manchuria (Minn. No. 105)	354	....	....	....	....	7.6	6.6	....	....	....	....	....	....	....	....	....
Manchuria (Minn. No. 6)	638	....	19.8	5.2	0	8.1	8.0	4.2	62.1	20.2	12.9	18.3	9.0	15.3	17.9	24.5
Manchuria	643	26.0	17.3	4.3	0	7.2	....	....	....	....	....	....	....	....	....	....
Six-rowed, hulled, black:																
Gatami	575	....	....	....	....	18.3	8.2	6.9	50.6	28.2	26.0	14.4	7.1	....	20.0	25.3
Six-rowed, naked, awned:																
Himalaya (Guy Mayle)	620	....	....	....	....	....	....	....	58.4	18.3	12.4	12.7	5.4	....	....	21.4
Six-rowed, naked, hooded:																
Nepal (White Hull-less)	595	12.0	9.0	1.7	0	10.7	8.9	4.9	50.8	13.1	9.5	8.7	2.0	10.8	13.6	16.8
Do	262	16.3	9.6	2.5	0	....	....	....	....	....	....	....	....	....	....	....
Two-rowed, hulled:																
Chevalier II	530	....	22.1	0	0	0	6.8	1.1	....	....	....	....	....	....	....	....
Hanna	24	29.0	23.8	1.0	0	0	10.7	2.7	....	....	....	....	....	....	....	....
Do	203	27.9	21.4	1.4	0	0	....	....	....	....	....	....	....	....	....	....
Hannchen	531	....	19.2	3.1	0	0	12.7	6.7	85.9	23.5	17.5	23.6	6.1	18.0	22.0	31.3
White Smyrna (Ouchac)	658	....	....	....	....	10.7	14.3	14.4	76.2	24.6	23.3	18.4	9.2	....	23.9	30.3
Do	195	....	....	....	....	....	....	....	77.9	....	....	....	....	....	....	....

The yields of the naked varieties Himalaya and Nepal have been much less than those of the hulled varieties. If the weights of the glumes are considered, the average yield of Himalaya has been equal to that of several of the hulled varieties, though not to the best. The Nepal is not sufficiently vigorous to be productive.

The average dates of heading and maturity, height, weight per bushel, and yields of grain and straw for four varieties of barley are shown in Table XXIII. The Hannchen variety shows a considerably later date of heading than the other varieties, but this is partly due to the failure of the heads to emerge promptly or fully from the sheath, even though they were well developed. The Hannchen has the heaviest weight per bushel and the highest yields of grain and straw. The Odessa and Manchuria varieties were taller than the Nepal and Hannchen.

TABLE XXIII.—*Average agronomic data for four varieties of barley grown on dry land on the Belle Fourche Experiment Farm, 1909 to 1919, inclusive.*

Group and variety.	C. I. No.	Date of—		Height.[a]	Weight per bushel.[a]	Yields per acre.	
		Heading.[a]	Maturity.[a]			Grain.	Straw.[a]
				Inches.	*Pounds.*	*Bushels.*	*Pounds.*
Six-rowed, hulled:							
Odessa	182	July 2	July 20	25	42.7	17.6	1,217
Manchuria (Minn. No. 6)	638	July 5[b]	July 22	24	42.4	15.3	1,048
Six-rowed, naked, hooded:							
Nepal (White Hull-less)	595	July 3[c]	July 24	21	57.4	10.8	1,053
Two-rowed, hulled:							
Hannchen	531	July 13[d]	July 24[e]	[e]21	[e]45.1	18.0	1,254

[a] Average for 9 years, 1909, 1910, 1912 to 1917, and 1919.
[b] Average for 8 years, 1909, 1910, 1912, 1913, 1915 to 1917, and 1919.
[c] Average for 8 years, 1909, 1910, and 1912 to 1917.
[d] Average for 4 years, 1909 and 1915 to 1917.
[e] Average for 8 years, 1909, 1910, 1913 to 1917, and 1919.

NURSERY EXPERIMENTS.

The nursery experiments with barley consisted almost entirely of tests of varieties. No promising varieties not already being grown in plats were observed in the nursery experiments. Progenies from a few natural hybrids of barley found in the plats at Newell were grown for observation. The strains isolated were not as promising as other varieties previously mentioned.

RATE-OF-SEEDING EXPERIMENTS.

Rate-of-seeding experiments with White Smyrna barley, C. I. No. 658, were begun in 1917 and conducted for three years. The barley was sown at four different rates, ranging from 4 to 10 pecks per acre. The data are not entirely conclusive, but are of considerable interest. The yields are shown in Table XXIV.

The highest average yield was obtained from the plats sown at the rate of 4 pecks per acre. In 1917, however, the 8-peck rate gave the highest yield. The barley in the varietal experiments usually has been sown at the rate of 5 pecks per acre, and from the average results shown in Table XXIV this rate appears to be ample. On a well-prepared seed bed the sowing of 4 pecks of clean barley seed per acre apparently is sufficient.

TABLE XXIV.—*Yields of White Smyrna barley grown in rate-of-seeding experiments on dry land on the Belle Fourche Experiment Farm, 1917 to 1919, inclusive.*

Rate of seeding per acre.	Yields per acre (bushels).			
	1917	1918	1919	Average.
4 pecks	28.7	25.7	9.7	21.4
6 pecks	31.3	20.9	9.4	20.5
8 pecks	33.3	18.0	8.7	20.0
10 pecks	28.2	19.3	8.0	18.5

EXPERIMENTS WITH MINOR CEREALS.

The cereals of minor importance which were grown in experiments on dry land at Newell are proso, rye, emmer, spelt, buckwheat, and the grain sorghums.

The work with these, with the exception of proso, has not been very extensive.

SPRING EMMER.

One variety of spring emmer, Vernal (White Spring), has been grown on dry land each year since 1908. No crop was produced in 1911, 1912, and 1914. The highest yield, 3,513 pounds per acre, was obtained in 1915. Emmer is severely injured by extreme drought and under such conditions it yields considerably less than adapted varieties of barley. Table XXIX (p. 41), showing a comparison of yields of the various grain crops, presents the yields of Vernal emmer in pounds per acre for five years from 1913 to 1917, inclusive. Vernal emmer yielded an average of 1,179 pounds per acre, compared with yields of 1,378, 1,415, and 1,405 pounds per acre, respectively, for Kubanka wheat, Kherson oats, and Hannchen barley. Under conditions at Newell the better varieties of oats and barley may be expected to yield considerably more grain per acre than emmer.

WINTER EMMER AND SPELT.

Winter emmer has been grown in both the plat and nursery experiments on dry land. Black Winter emmer, C. I. No. 2337, was grown in plats in 1909, but only 1 per cent of the plants survived the winter. It has been grown in the nursery for several seasons since then, but the yields and winter survival were always low. Buffum Improved Black Winter emmer, C. I. No. 3331, was grown in plats from 1913 to 1917, inclusive. The crop was entirely winterkilled in 1917, and the spring survival was low in the other seasons, not more than one-third of the plants surviving even the mildest winters.

The yields of Buffum Improved Black Winter emmer are shown in Table XXIX (p. 41). The average yield for the 5-year period from 1913 to 1917, inclusive, was 639 pounds per acre, compared with 1,800 pounds of Kharkof winter wheat. Considering the low market and feeding value and the low winter survival and yield of the winter emmer, it can not be recommended for growing in western South Dakota.

A single variety of winter spelt was grown in 1917. This was a brown winter spelt, the seed of which had been imported from Switzerland, about 1913, by a farmer in the vicinity. Although this was slightly hardier than winter emmer, it was much inferior to winter wheat in both yield and value.

RYE.

Spring rye has not been grown at Newell except in 1908 and the crop was not very successful. Winter rye is considered much more promising. Winter rye was grown from 1913 to 1917, inclusive. Only one variety, Swedish (Minn. No. 2), C. I. No. 137, has been grown in plats on dry land. In 1913 this was injured at flowering time by hot winds, which caused considerable floret sterility and also before maturity by a hailstorm which shattered much of the grain. The 1914 and 1917 crops were reduced by drought, the 1915 crop was slightly injured by rust, and the 1916 crop by both drought and rust. The yields ranged from 5.3 bushels in 1913 to 44.5 bushels per acre in 1915. The 5-year yield is 20.6 bushels per acre. The yield of Swedish winter rye in pounds per acre in comparison with winter wheat and several spring grains is shown in Table XXIX (p. 41). The rye has yielded less than winter wheat, spring wheat, oats, and barley, and is consequently considered a less profitable crop to grow. However, it is hardier and more certain than winter wheat and can be sown later. The greater hardiness of winter rye is shown in figure 8. Rye may be drilled in small grain stubble in the fall, with fair chances of obtaining a crop of grain or hay.

Two other varieties of winter rye have been grown in nursery experiments. One of these, North Dakota No. 959, is very hardy, but neither this nor the other variety, known as C. I. No. 178, yielded as well as the Swedish variety.

BUCKWHEAT.

The growing of buckwheat on dry land was attempted only in 1908. No seed was matured. Apparently buckwheat is not adapted to growing under the dry conditions which usually prevail at Newell.

PROSO.

Proso,[9] or hog millet, is an early maturing millet the seed of which is used for grain. It is best adapted to the northern Great Plains and prairie sections, where it is grown to a limited extent as a catch crop. It is well suited to the climatic conditions in South Dakota. Other spring cereals on the average produce more grain per acre than proso, but in some seasons proso has outyielded all other spring grain crops. It can be sown even as late as July 1 and still mature seed.

VARIETAL EXPERIMENTS.

Varietal experiments with proso were begun in 1908, when a few varieties were grown in plats and several others in rows. From 1909

[9] For further information concerning proso, see Farmers' Bulletin 1162, "Proso, or hog millet," by John H. Martin, 15 p., 4 fig. 1920.

to 1915, inclusive, because of the minor importance of the crop, the proso varieties were grown only in rows. These rows usually were 60 feet long and replicated two or three times. During this period the highest average yields were obtained from the Turghai and Red Russian varieties.

In 1916 a few of the leading varieties of proso from the nursery row experiments were sown in plats. These were continued for three years more and several additional varieties also were grown in 1917 and 1919. The Dakota Kursk, a millet of the foxtail group, was included in both the nursery and plat experiments for comparison with the prosos. The yields of the varieties are shown in Table XXV.

TABLE XXV.—*Yields of proso varieties grown on dry land on the Belle Fourche Experiment Farm, 1916 to 1919, inclusive.*

Group and variety.	C. I. No.	Yields per acre (bushels).				
		1916	1917	1918	1919	Average.
Spreading, white seeded:						
White Ural	4	24.1	23.7	44.3	5.5	24.4
"White"	78	.....	11.8	.....	5.8	.....
Hansen	179	27.2	18.8	33.6	9.7	22.3
Spreading, red seeded:						
Red Russian	61	25.0	17.5	55.4	13.2	27.8
Turghai	31	21.4	18.2	.....	13.1	.....
Loose, yellow seeded:						
Yellow Manitoba	101	.....	15.4	.....	11.3	.....
Loose, black seeded:						
Black Voronezh	27	[a] 23.5	16.4	38.8	14.0	23.2
Compact, red seeded:						
Red Voronezh	26	.....	15.4	.....	8.9	.....
Yellow Sarepta	17	.....	13.6	.....	9.2	.....
Foxtail millet:						
Dakota Kursk	.....	.....	6.3	.....	12.8	.....

[a] Grown in a spacing test adjoining other varieties.

As shown in Table XXXVI, the Red Russian variety produced the highest average yield during the 4-year period. The White Ural, the next highest yielding variety, produced 3.4 bushels per acre less than Red Russian. Both the Black Voronezh and the Hansen yielded less than the White Ural. The Turghai was the highest yielding variety in the nursery experiments, but it did not yield as well as Red Russian in the plat experiments. It was not grown in plats in 1918, however.

Average agronomic data for the proso varieties grown in 1917 and 1919 are shown in Table XXVI.

TABLE XXVI.—*Average agronomic data for the proso varieties grown in plats on dry land on the Belle Fourche Experiment Farm in 1917 and 1919.*

Group and variety.	C. I. No.	Date of—		Height.	Weight per bushel.	Yields per acre.	
		Heading.	Maturity.			Seed.	Straw.
Spreading, white seeded:				*Inches.*	*Pounds.*	*Pounds.*	*Pounds.*
White Ural	4	Aug. 8	Aug. 22	18	53.6	817	1,212
Hansen	179	...do....	Aug. 23	23	54.1	797	1,012
Spreading, red seeded:							
Red Russian	61	Aug. 9	Aug. 24	24	55.7	861	1,300
Turghai	31	Aug. 11	Aug. 29	25	55.8	876	1,762
Loose, yellow seeded:							
Yellow Manitoba	101	...do....	...do....	29	55.5	748	1,300
Loose, black seeded:							
Black Voronezh	27	Aug. 12	Aug. 31	29	57.0	851	1,533
Compact, red seeded:							
Red Voronezh	26	Aug. 10	Aug. 26	20	55.8	681	1,037
Yellow Sarepta	17	...do....	Aug. 25	20	56.2	639	937
Foxtail millet:							
Dakota Kursk	.....	Aug. 26	Sept. 16	20	52.2	535	1,180

RATE-OF-SEEDING EXPERIMENTS.

A rate-of-seeding experiment with Hansen proso was conducted on dry land in 1917. The experiment was sown at three different rates, in triplicate, on June 19. The plats sown at 15 pounds per acre yielded an average of 20.3 bushels, those sown at 22.5 pounds yielded 22.3 bushels, while those sown at 30 pounds yielded 23.0 bushels per acre. It is thus seen that the 30-pound rate gave a slightly higher net yield than the 22.5-pound rate. Under conditions of earlier seeding or late drought a thinner seeding might have given the highest yield. Conclusions can not be drawn from a 1-year experiment, but apparently not less than 25 to 30 pounds of proso should be sown per acre for best results under the conditions at Newell.

SPACING EXPERIMENTS.

Black Voronezh proso was grown in an experiment in 1916 and 1917 to determine the distance between drill rows which would produce maximum yields. The seed was sown with the grain drill in rows 7, 14, and 21 inches apart in triplicated plats. The drill was set in the same notch for all spacings, so that the plats having rows 7 inches apart were sown at the rate of about 28 pounds per acre, those with rows 14 inches apart at the rate of 14 pounds per acre, and those in rows 21 inches apart at about 8.5 pounds per acre. The yields from the experiment are shown in Table XXVII.

TABLE XXVII.—*Yields of Black Voronezh proso grown in spacing experiments on dry land on the Belle Fourche Experiment Farm in 1916 and 1917.*

Distance between rows.	Yields per acre, bushels.		
	1916	1917	Average.
7 inches	26.1	24.4	25.2
14 inches	23.5	20.9	22.2
21 inches	16.0	16.7	16.3

The average yield from the plats sown in the regular 7-inch drill rows was 25.2 bushels, from the 14-inch rows 22.2 bushels, and from the 21-inch rows 16.3 bushels per acre. Proso has rather coarse stems and spreading branches, and it was thought that the wider spacing might show a slight advantage. The yields, however, were strongly in favor of the thick spacing. Unfortunately, the rates of seeding were different with each spacing, but the results obtained in this and the rate-of-seeding experiment previously described seem to indicate that proso should be sown in drill rows about 7 or 8 inches apart at a rate not less than 25 to 30 pounds per acre.

EXPERIMENT WITH GRAIN SORGHUMS.

One or more varieties of grain sorghum were sown at Newell each year from 1908 to 1917, except in 1911, when the soil was too dry for the seed to germinate. Most types did not produce seed and did not always form heads because of the cool weather. The only varieties which matured seed were extremely early, and included Manchu Brown kaoliang, Dwarf milo, and Freed sorgo. The Dwarf milo produced seed only in 1913. The yields of the leading grain-sorghum varieties are shown in Table XXVIII.

TABLE XXVIII.—*Yields of the leading varieties and strains of grain sorghum grown on dry land on the Belle Fourche Experiment Farm, 1908 to 1917, inclusive.*

Group and variety.	C. I. No.	Yield per acre (bushels).									
		1908[c]	1909[b]	1910[a]	1912	1913[b]	1914[c]	1915[c]	1916[c]	1917[d]	Average, 1909 to 1917.
Kaoliang:											
Manchu Brown	171	22.9	.....	7.1	0	5.0	4.6	0	0	.....	.....
Manchu Brown Selection 3–1	261	.....	18.9	.....	0	6.2	3.5	0	0	.....	.....
Manchu Brown Selection 3–5	261	.....	13.2	12.2	0	4.6	1.5	0	.....	.....	.....
Manchu Brown Selection 4	261	.....	12.3	11.6	0	6.2	2.5	0	0	.....	.....
Manchu Brown	328	.....	9.4	8.0	0	4.2	6.6	0	0	23.6	6.5
Milo:											
Dwarf	.....	.....	.....	.....	.....	5.0	0	0	0	.....	.....
Sorgo:											
Freed	.....	.....	.....	.....	.....	5.8	6.0	0	0	.....	.....

[a] Yield calculated from that of an 80-foot row.
[b] Yield calculated from that of a 132-foot row.
[c] Yield calculated from that of two 132-foot rows.
[d] Yield calculated from that of a tenth-acre plat.

Strains of Manchu Brown kaoliang produced the highest yields during all of the years from 1909 to 1916, inclusive. Complete failures were recorded in 1912, 1915, and 1916, on account of early frosts which killed the plants before the grain was ripe. Drought and frost caused low yields in all other years except 1917, when a yield of 23.6 bushels of nearly mature kaoliang was obtained. The grain sorghums have yielded less than any of the other grains at Newell and are not adapted to the prevailing climatic conditions.

COMPARISON OF GRAIN CROPS.

A comparison of the yields in pounds per acre of all grains on the dry land at Newell are shown in Table XXIX. The yields shown are for the 5-year period from 1913 to 1917, inclusive, when nearly all of the small grains were being grown in plats. For the entire period of the cereal experiments at Newell the comparative yields of the crops would be somewhat different. The crops were not all grown under comparable conditions each year. However, the rye, winter emmer, and spelt were sown in the same series and on the same date as the winter wheat. The yields of spring wheat shown were obtained from replicated plats sown in the winter-wheat series each spring. The spring emmer was grown along with the barley varieties. The oats usually were sown in the same series with barley. The proso and kaoliang usually were sown on the same date and on adjoining land.

TABLE XXIX.—*Yields of the leading varieties of different grain crops grown on dry land on the Belle Fourche Experiment Farm from 1913 to 1917, inclusive.*

Crop, group, and variety.	Yields per acre (pounds).						
	C. I. No.	1913	1914	1915	1916	1917	Average.
Crimean winter wheat:							
Kharkof	1442	2,316	1,722	3,828	852	282	1,800
Durum spring wheat:							
Kubanka	1440	1,074	1,014	2,940	1,014	846	1,378
Winter emmer:							
Buffum Black Winter	3331	1,035	1,248	848	625	0	639
Spring emmer:							
Vernal (White Spring)	1524	500	0	3,513	1,100	781	1,179
Winter spelt:							
Brown Winter	.....	.....	.....	.....	.....	100	.....
Winter rye:							
Swedish (Minn. No. 2)	137	296	890	2,497	1,116	980	1,156
Spring oats:							
Kherson	459	700	442	3,547	1,305	1,081	1,415
Spring barley:							
Hannchen	531	609	321	4,123	1,133	840	1,405
Proso:							
Red Russian	61	0	[a] 704	[a] 1,368	1,400	980	890
Kaoliang:							
Manchu Brown	328	244	383	0	0	1,368	399

[a] Yields from two 60-foot rows.

The average yield of Kharkof winter wheat during the five years was 1,800 pounds per acre. Kherson oats yielded at the rate of 1,415 pounds per acre, Hannchen barley 1,405 pounds, and Kubanka spring wheat at the rate of 1,378 pounds per acre. Other cereal crops yielded less than the spring wheat. The period from 1913 to 1917 was usually favorable for winter wheat, but this crop, although rather uncertain, may be expected to yield more than other cereals on the average. The yields in pounds per acre of well-adapted varieties of spring wheat, oats, and barley are nearly the same. The Manchu Brown kaoliang, because of its resistance to early drought, outyielded all other crops in 1917. In 1916 the Red Russian proso produced more grain than the other crops. This was

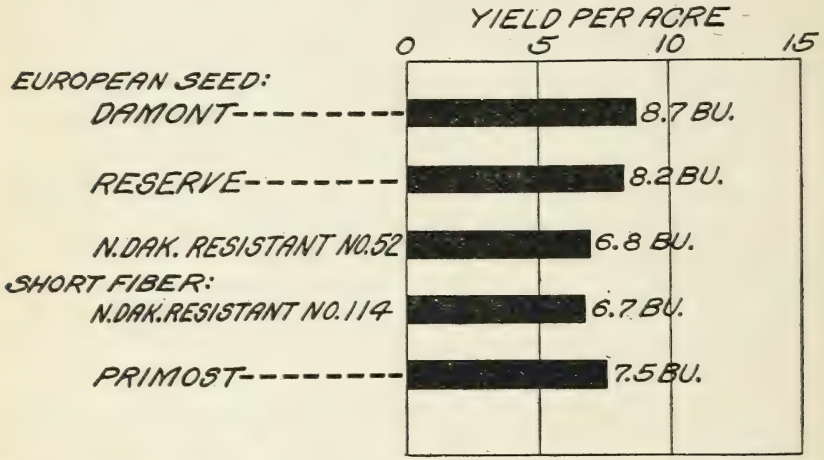

FIG. 13.—Diagram showing the average yields, in bushels per acre, of the leading varieties of flax on dry land at the Belle Fourche Experiment Farm for the 6-year period from 1914 to 1919, inclusive.

partly because the kaoliang was frosted, while the other crops were injured by rust, soil blowing, or drought.

EXPERIMENTS WITH FLAX.

Flax is a crop usually grown on new sod land. However, when grown in rotation on land fairly free from weeds it can be grown successfully on land which has been previously cropped. The yields of flax at Newell have compared rather favorably with the small grains when the value of the crop is considered. Flax is less certain than the small grains, as it is more easily injured by drought, frost, and soil blowing.

VARIETAL EXPERIMENTS.

The varietal experiments with flax were begun in 1912. Twelve varieties have been grown in plats on dry land during the period

of the experiments, but only three varieties were grown all of the seasons. Good yields of flax were obtained in 1912, 1915, and 1918, fair yields in 1916 and 1917, and poor yields in 1913 and 1914, while the crop was a complete failure in 1919. The yields depended chiefly upon the seasonal precipitation. Very little injury from diseases was observed. The yields are shown in Table XXX.

It will be observed (Table XXX) that the Damont variety, C. I. No. 3, gave the highest average yields during both the 6-year and 8-year periods. The next highest yields were obtained from the Reserve variety, C. I. No. 19. This variety was formerly known as Russian and North Dakota No. 155. The wilt-resistant varieties, North Dakota Resistant Nos. 52 and 114, have not yielded as well as the other varieties. None of the varieties has been reduced in yield by wilt injury. The average yields of the flax varieties from 1914 to 1919, inclusive, are shown in figure 13.

TABLE XXX.—*Yields of flax varieties grown on dry land on the Belle Fourche Experiment Farm, 1912 to 1919, inclusive.*

Group and variety.	C. I. No.	Yields per acre (bushels).									
										Average.	
		1912	1913	1914	1915	1916	1917	1918	1919	1912 to 1919.	1914 to 1919.
European seed:											
Select Russian (N. Dak. No. 608)	1	10.6	3.3	2.2	.....	.....	.....	.....	.....	.....	.....
Select Riga (N. Dak. No. 1214)	2	10.6	.....	.....	.....	.....	.....	.....	.....	.....	.....
Damont (N. Dak. No. 1215)	3	11.2	5.6	.7	23.6	7.6	7.2	13.1	0	8.6	8.7
Kazan (N. Dak. No. 1329)	4	8.2	.....	.....	.....	.....	.....	.....	.....	.....	.....
Stepan (N. Dak. No. 1340)	5	0	.....	.....	.....	.....	.....	.....	.....	.....	.....
Frontier (N. Dak. No. 155)	17	7.5	.....	.....	.....	.....	.....	.....	.....	.....	.....
Reserve	19	8.9	5.2	.8	22.0	7.7	6.9	11.6	0	7.9	8.2
N. Dak. Resistant No. 52	8	.....	4.5	2.4	[a]12.3	7.1	6.2	12.9	0	.....	6.8
Short fiber:											
N. Dak. Resistant No. 114	13	.....	.....	1.5	16.7	5.8	6.3	10.1	0	.....	6.7
Primost (Minn. No. 25)	12	9.1	4.8	1.7	17.8	6.2	6.9	12.4	0	7.4	7.5
Turkish:											
Turkish	7	11.4	2.8	2.4	.....	.....	.....	.....	.....	.....	.....
Smyrna	30	.....	.....	.....	18.1	2.9	.....	.....	.....	.....	.....

[a] Reseeded, first seeding failed to emerge.

RATE-OF SEEDING EXPERIMENTS.

Rate-of-seeding experiments with flax on dry land were conducted in 1912 and again from 1915 to 1918, inclusive. The variety used was "common" flax in 1912, Primost in 1915 and 1916, and Damont in 1917 and 1918. Except in 1912, sowings were made at three rates, viz, 15, 22.5, and 30 pounds per acre. The highest average yields were obtained from the plats sown at the rate of 30 pounds per acre. During the five years, 1912 and 1915 to 1918, inclusive, the 30-pound rate gave an average yield of 0.8 bushel per acre more than the 15-

pound rate. The net increase for the 30-pound rate is only about 0.5 bushel, which probably is not significant. However, these experiments were all conducted on a well-prepared seed bed, and probably the results from the 15-pound rate are better than would be obtained under ordinary seed-bed conditions. The best rate of sowing for flax on dry land at Newell probably is about 2 pecks (28 pounds) per acre. The data from the rate-of-seeding experiments are shown in Table XXXI.

TABLE XXXI.—*Yields of flax*[a] *grown in rate-of-seeding experiments on dry land on the Belle Fourche Experiment Farm in 1912 and from 1915 to 1918, inclusive.*

Rate of seeding per acre.	Yields per acre (bushels).						
						Average.	
	1912	1915	1916	1917	1918	1915 to 1918	1912 and 1915 to 1918
15 pounds	9.6	23.6	8.2	7.8	9.2	12.2	11.7
22½ pounds	.....	25.6	8.4	7.8	7.9	12.4	.....
30 pounds	11.2	27.0	7.2	7.4	9.5	12.8	12.5

[a] Common flax used in 1912: Primost, C. I. No. 12, in 1915 and 1916; and Damont, C. I. No. 3, in 1917 and 1918.

TABLE XXXII.—*Yields of flax grown in date-of-seeding experiments on dry land on the Belle Fourche Experiment Farm, 1912, 1913, and 1915 to 1919, inclusive.*

Date of seeding.	Yields per acre (bushels).						
	1912	1913	1915	1916	1917	1918	Average, 1917 to 1918.
April 20 to 25	.....	.....	.....	(a)	5.8	9.2	7.5
May 2 to 8	.....	7.7	20.0	6.3	5.3	10.8	8.0
May 15 to 20	8.3	.....	.....	.....	5.5	11.4	8.4
May 20 to 25	.....	4.8	21.5	6.9	.....	.....	.....
June 1 to 10	10.6	3.0	(b)	.....	4.2	6.5	5.4

[a] Early seeding blown out. [b] Did not emerge.

DATE-OF-SEEDING EXPERIMENTS.

Date-of-seeding experiments with flax were conducted in 1912, 1913, and 1915 to 1918, inclusive. The Primost variety (C. I. No. 12) was grown in 1912, 1913, and 1915 and Damont (C. I. No. 3) in 1916, 1917, and 1918. Sowings were made on two, three, or four dates each season. The dates of seeding were not the same each year, because the soil frequently was too wet when the sowings should have been made. Because of the variable seasons and the irregularities in the experiment it is difficult properly to summarize

the yield data. In 1913 and 1917 the earliest dates of seeding gave the highest yields; in 1912, 1915, and 1916 the latest dates gave the highest yields, while in 1918 the medium dates were most favorable. The flax in the last sowing in 1915 did not emerge and that from the earliest sowing of 1916 was blown out. Late summer rains in 1912 favored late sowing of flax, but in general the yields from flax sown after May 20 were comparatively low. The best date of seeding for flax on dry land at Newell, although undetermined, probably occurs between April 15 and May 15. The data are shown in Table XXXII.

EXPERIMENTS ON IRRIGATED LAND.

In 1912 a large part of the Belle Fourche Experiment Farm was placed under irrigation, and experiments with cereals on the irrigated land were begun at that time. A few varieties of spring wheat, oats, barley, and flax were sown on irrigated land in 1912, 1913, and 1914. In 1915 the number of plats was increased to include experiments with winter wheat and grain mixtures, and in 1916 and thereafter a number of additional experiments were in progress. The irrigated plats were one twenty-fifth of an acre each in 1912 and 1913, but in 1914 and thereafter nearly all experiments were conducted in triplicated fiftieth-acre plats.

Most of the cereals grown under irrigation were sown on land which had produced an intertilled crop, such as corn, potatoes, roots, or sunflowers, the previous year. The land was double disked and harrowed or "floated" before seeding. The cereal crops received two and sometimes three irrigations during the season. The time of irrigation was gauged by the condition of the soil rather than by the stage of growth of the grain, because it was practically useless to irrigate until the surface soil was sufficiently dry and cracked to take up water. The quantity of water applied was not measured, but was approximately 4 or 5 acre-inches at each application. Water was applied by flooding from field ditches, which usually were constructed along the ends of the plats.

The average yields from the irrigated land are not greatly in excess of those from the same crops grown on the dry land. In 1915 the yields on dry land were much higher than on irrigated land.

From 1912 to 1915, inclusive, the irrigation experiments were conducted on rather unfavorable soil, while in 1916 most of the crops were damaged by soil blowing and rust. The irrigated grains were sown on previously cropped land following either small grain or an intertilled crop, while many of the dry-land experiments were conducted on summer fallow. In most seasons the grains were sown on the dry land earlier than on the irrigated land, chiefly because the

soil was dry enough to be in condition for seeding before the irrigated land. This favored higher yields from the dry land.

On the whole, the yields from the cereal plats on irrigated land are considerably higher than the average for the region, where the conditions, as on the Belle Fourche Experiment Farm, usually are not favorable for maximum grain yields.

EXPERIMENTS WITH WHEAT.

SPRING WHEAT.

VARIETAL EXPERIMENTS.

Ten varieties of spring wheat have been grown in the experiments on irrigated land. Three of these were grown during the entire period from 1912 to 1919. The experiments were on rather poor soil from 1912 to 1915. The seeding was late in 1915. In 1916 the wheat

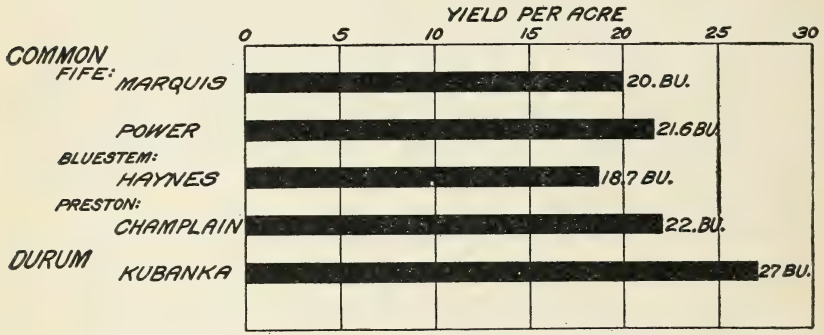

FIG. 14.—Diagram showing the average yields, in bushels per acre, of the leading varieties of spring wheat on irrigated land at the Belle Fourche Experiment Farm for the 6-year period from 1914 to 1919, inclusive.

was damaged by soil blowing and also was severely attacked by rust. Good yields of most varieties of spring wheat were obtained in 1917, 1918, and 1919. The yields of the spring-wheat varieties on irrigated land are shown in Table XXXIII. The average yields for six years also are shown in figure 14.

The average yield of the Kubanka variety during the 8-year period, 1912 to 1919, inclusive, was 25.2 bushels per acre. During this same period Power yielded 20.8 bushels and Haynes Bluestem 18.6 bushels per acre. During the 6-year period, 1914 to 1919, inclusive, Kubanka yielded an average of 27 bushels per acre. The next highest yielding variety was Champlain, which produced 22 bushels per acre. Marquis during this period yielded only 20 bushels per acre. This was partly due to poor growth in 1917 and 1919. In 1917 the Marquis was sown at 4 pecks per acre, by mistake, while the other varieties were sown at the rate of 5 pecks per acre. The

average yield of Power is 1.6 bushels per acre higher than Marquis, but because of the irregularities just mentioned this difference may not be significant. Marquis is the leading variety of wheat in the vicinity of Newell and, because of its high quality, earliness, and short, strong straw, is probably to be preferred to other common wheats for growing on irrigated land. The Kubanka, a durum wheat, has outyielded all other varieties to such an extent as to make it the most profitable variety. Even at the lower price obtained for irrigated durum wheat, the net return doubtless will be higher than from any of the common wheats.

TABLE XXXIII.—*Yields of the varieties of spring wheat grown on irrigated land on the Belle Fourche Experiment Farm, 1912 to 1919, inclusive.*

Class, group, and variety.	C. I. No.	Yields per acre (bushels).									
										Average.	
		1912[a]	1913	1914	1915	1916	1917	1918	1919	1912 to 1919	1914 to 1919
COMMON.											
Fife:											
Marquis	3276	.....	18.3	18.3	18.0	9.4	[b]20.1	35.0	19.4	.....	20.0
Power	3025	19.5	17.0	17.0	14.7	8.4	27.3	35.0	27.5	20.8	21.6
Saskatchewan Fife	.....	.....	.....	14.9	12.1	.....	.....	.....	.....	.....	.....
Ghirka Spring	1517	16.4	.....	.....	.....	.....	.....	.....	.....	.....	.....
Bluestem:											
Haynes Bluestem	2874	22.0	14.2	15.4	11.5	7.3	19.8	30.7	27.5	18.6	18.7
Preston:											
Champlain	4872	.....	.....	19.0	12.2	6.5	29.5	37.6	27.3	.....	22.0
Unclassified:											
Regenerated Defiance	3703	.....	11.7	18.0	8.0	2.0	.....	.....	.....	.....	.....
Dicklow	3663	.....	.....	.....	.....	.....	.....	.....	19.4	.....	.....
DURUM.											
Acme	5284	.....	.....	.....	.....	.....	.....	39.2	26.1	.....	.....
Kubanka	1440	20.8	18.6	22.8	22.0	20.6	25.2	41.7	29.7	25.2	27.0

[a] Grown in single plats in 1912. [b] Sown at a lower rate.

The Haynes Bluestem variety is late, easily injured by rust, easily shattered when ripe, and a rather poor yielder. The average yield of this variety during the 8-year period is 6.6 bushels per acre less than Kubanka.

The Champlain variety, also called Pringle's Champion, is an awned variety having semihard to hard red kernels. This wheat is apparently of lower quality than Marquis, Power, or Haynes Bluestem.

Two varieties of white wheats have been grown, but without much success. The Regenerated Defiance was severely injured by rust in both 1915 and 1916 and was discontinued from the experiments. The Dicklow variety, a soft white wheat extensively grown under irrigation in Idaho, was included in the experiments in 1919 only. It was outyielded by all varieties except Marquis, which yielded the same.

The Acme variety, a rust-resistant durum wheat originated at the Highmore (S. Dak.) substation, has not yielded as well as Kubanka under irrigation.

TABLE XXXIV.—*Average agronomic data for five varieties of spring wheat grown on irrigated land on the Belle Fourche Experiment Farm, 1914 to 1917, inclusive, and in 1919.*

Class, group, and variety.	C. I. No.	Date of—		Height.	Weight per bushel.	Yields per acre.	
		Heading.	Maturity.			Grain.	Straw.
COMMON.							
Fife:				*Inches.*	*Pounds.*	*Bushels.*	*Pounds.*
Marquis	3276	July 13	Aug. 8	29	58.3	17.0	1,409
Power	3025	July 15	Aug. 10	31	58.6	19.0	1,729
Bluestem:							
Haynes Bluestem	2874	July 17	Aug. 14	35	56.0	16.3	1,666
Preston:							
Champlain	4872	July 14	Aug. 10	33	57.7	18.9	1,511
DURUM.							
Kubanka	1440	July 12	Aug. 11	35	62.3	24.1	1,708

Table XXXIV shows the average dates of heading and maturity, the average height, weight per bushel, and yields of grain and straw of five of the varieties of spring wheat grown from 1914 to 1917, inclusive, and in 1919. The Marquis variety is the earliest and shortest. The Haynes Bluestem averaged six days later in maturity than Marquis and gave the lowest weight per bushel of any of the varieties. Kubanka, a durum wheat, had an average weight per bushel of 62.3 pounds.

NURSERY EXPERIMENTS.

The nursery experiments with spring wheat on the irrigated land consisted in the growing of a considerable number of foreign varieties in preliminary row tests. Nothing of unusual value was observed in the experiments.

WINTER WHEAT.

VARIETAL EXPERIMENTS.

The varietal experiments with winter wheat under irrigation were begun in the fall of 1914, when seven varieties and strains were sown. The wheat was sown on land which had been both irrigated and summer-fallowed and was thus in excellent condition for producing a crop. The resulting yields were quite large, but this was partly due to the very favorable season of 1915.

In 1916 and 1918 the winter-wheat varieties were sown on cornland which was irrigated, disked, and harrowed before seeding. Figure 15 shows construction of a ditch to irrigate the cornland before sowing winter wheat. The 1916 crop was greatly reduced by

stem rust. The wheat did not fully emerge in the fall of 1917. The 1917 crop was sown on beet land which had previously produced alfalfa. The wheat was partly destroyed by an accidental flooding late in the fall. Although the stands were thin the yields were fairly high in 1917.

The annual and average yields are shown in Table XXXV.

FIG. 15.—Constructing an irrigation ditch on the Belle Fourche Experiment Farm. The corn ground is irrigated before sowing it to winter wheat.

TABLE XXXV.—*Yields of varieties of winter wheat grown on irrigated land on the Belle Fourche Experiment Farm, 1915 to 1918, inclusive.*

Group and variety.	C. I. No.	Yields per acre (bushels).				
		1915	1916	1917	1918	Average.
Crimean:						
Beloglina	1667	[a] 52.1	8.7	30.7	24.0	28.9
Kharkof	1583	66.3	11.3	29.5	23.4	32.6
Do	4207	61.3	.....	.....	.....	.....
Turkey	3055	.....	8.7	26.7	24.3	.....
Turkey selection	3055-159	66.6	11.5	31.0	26.5	33.9
Alton:						
Alton (Ghirka Winter)	1438	.....	8.8	19.9	.....	.....
Alton selection	5297	59.1	5.2	28.5	26.5	29.8
Do	5298	57.5	.....	.....	.....	.....
Do	1437-394	51.9	.....	.....	.....	.....

[a] One plat only.

In Table XXXV it will be observed that the Turkey selection, No. 3055–159, produced the highest yield each year. This strain

averaged 1.3 bushels per acre more than Kharkof, C. I. No. 1583, and also considerably outyielded the parent variety, Turkey, C. I. No. 3055, during the three years the latter was grown. The Beloglina yielded nearly as much as the other Crimean strains except in 1915, when only a single plat of that variety was grown, this being in an unfavorable location.

The awnless strains of the Alton (Ghirka Winter) group yielded less than the awned varieties of the Crimean group. The Alton variety was grown only in 1916 and 1917 and did not appear promising. Three other strains or selections of a type similar to Alton have been grown. Only one, C. I. No. 5297, an awnless selection or separation from Kharkof, was grown during each of the four years. Although this variety yielded somewhat less than Kharkof, it has the advantage of being awnless and is probably nearly equal to Kharkof in quality.

RATE-OF-SEEDING EXPERIMENTS.

Rate-of-seeding experiments with Kharkof wheat, C. I. No. 1442, were begun in the fall of 1915. The wheat was sown in triplicated fiftieth-acre plats at the rates of 3, 4, 5, and 6 pecks per acre. Results were obtained during three seasons.

The wheat was badly rusted in 1916, under which conditions the highest yields were obtained from the thickly sown plats. In 1917 and 1918 emergence was late and the stands of wheat were thin in the spring. The wheat was sown rather late during each of the three seasons, because of having to wait for the removal of the corn or root crop before preparing the land for wheat.

The yields are shown in Table XXXVI.

TABLE XXXVI.—*Yields of Kharkof winter wheat grown in rate-of-seeding experiments on irrigated land on the Belle Fourche Experiment Farm, 1916 to 1918, inclusive.*

Rate of seeding per acre.	Yields per acre (bushels).			
	1916	1917	1918	Average.
3 pecks	8.3	33.1	23.6	21.7
4 pecks	10.1	34.0	28.0	24.0
5 pecks	10.2	33.5	31.4	25.0
6 pecks	10.7	31.6	29.7	24.0

The highest average yield was obtained from the plats sown at the rate of 5 pecks per acre. The 6-peck rate gave the highest yield in 1916, the 4-peck rate in 1917, and the 5-peck rate in 1918. When the wheat is sown late the rate of seeding should be 5 pecks per acre. A seeding of less than 4 pecks per acre may be expected to cause reduced yields.

DEPTH-OF-SEEDING EXPERIMENTS.

Depth-of-seeding experiments with Kharkof winter wheats were conducted on irrigated land in 1917 and 1918. Only one fiftieth-acre plat was sown at each depth in 1917, but in 1918 the experiment was triplicated. The yields are shown in Table XXXVII.

TABLE XXXVII.—*Yields of Kharkof winter wheat grown in depth-of-seeding experiments on irrigated land in 1917 and 1918.*

Depth of seeding.	Yields per acre (bushels).		
	1917	1918	Average.
1 inch	24.5	35.9	30.2
1½ inches	30.0	34.2	32.1
2 inches	28.5	32.3	30.4

In 1917 the seeding at a depth of 1½ inches gave the highest yield, while in 1918 the highest average yield was obtained from seeding at a depth of 1 inch. The 1½-inch depth of seeding gave the highest average yield for the two years and, although the results are not very conclusive, this appears to be the most favorable depth.

COMPARISON OF SPRING AND WINTER WHEATS.

In 1916, 1917, and 1918, three plats of Kubanka durum spring wheat were sown in the spring in the same series with the winter-wheat varieties for comparison. During each of these years Kubanka considerably outyielded all of the winter-wheat varieties. In 1915 the winter wheat was sown under very favorable soil conditions and the yield was unusually high. The 4-year average yield of Kharkof, C. I. No. 1583, winter wheat was 32.6 bushels per acre, while Kubanka spring wheat yielded an average of 27.3 bushels. Because of the conditions in 1915, however, these yields are not quite comparable.

In the irrigated rotation experiments on the Belle Fourche Experiment Farm, conducted by the Office of Western Irrigation Agriculture, spring and winter wheat have been grown in continuous culture in adjoining plats each year since 1913. Since 1915 this test has been duplicated in another part of the rotation field on better soil. The yields on this good soil have been nearly twice as high as on the poorer soil. The average yields from the good and poor plats are used for comparison from 1915 to 1919, inclusive. The same variety of spring wheat was not used during all seasons. From 1913 to 1915, inclusive, Regenerated Defiance, C. I. No. 3703, was the variety used. In 1916 Marquis, C. I. No. 3276, was sown, but since 1917 Kubanka durum spring wheat was used. Because of the

greater yielding power and rust resistance of Kubanka, the yields of spring wheat doubtless would have been much higher had this variety been sown in the earlier years of the experiment.

The annual and average yields of spring and winter wheat in these experiments are shown in Table XXXVIII.

TABLE XXXVIII.—*Yields of winter and spring wheat varieties grown continuously in adjoining plats on irrigated land on the Belle Fourche Experiment Farm, 1913 to 1919, inclusive.*[a]

Group.	Yields per acre (bushels).[b]							
	1913	1914	1915	1916	1917	1918	1919	Average.
Winter	7.7	29.4	32.7	10.9	18.1	19.2	12.4	18.6
Spring[c]	15.5	19.2	20.0	8.6	24.5	17.4	13.4	16.9

[a] Data from rotation experiments of the Office of Western Irrigation Agriculture.
[b] Single plats in 1913 and 1914; average of two plats, 1915 to 1919, inclusive.
[c] Regenerated Defiance, C. I. No. 3703, in 1913, 1914, and 1915; Marquis, C. I., No. 3276, in 1916; and Kubanka, C. I., No. 1440, in 1917, 1918, and 1919.

Winter wheat outyielded spring wheat in these experiments in four out of seven years. The 7-year average yield of Turkey winter wheat was 18.6 bushels per acre. The adjoining plats of spring wheat produced an average yield of 16.9 bushels during the same period. In general, winter wheat may be slightly more productive than spring wheat under irrigation, but in many seasons the reverse is true. Winter wheat is not as well suited to growing under irrigation as spring wheat because of the rotation scheme. Wheat on irrigated land is usually sown after an intertilled crop, such as corn, roots, or potatoes. These crops are usually not removed from the ground until rather late for sowing winter wheat. When winter wheat is sown following a small-grain crop, it is necessary to plow and irrigate the land rather promptly after the previous crop is thrashed. Spring wheat also is a more convenient nurse crop for alfalfa, sweet clover, or grasses, which frequently are sown with the grain.

EXPERIMENTS WITH OATS.

VARIETAL EXPERIMENTS.

The experiments with oat varieties under irrigation were begun in 1912. Fifteen varieties have been grown in plats, but only four of these were grown during all of the eight years. Fair or good crops were obtained each season, but the yields are not large. The crop was almost free from diseases or other injury, so that the yields were chiefly limited by the character of the growing season, seed bed, and soil fertility. The yields of the oat varieties are shown in Table XXXIX.

During the 8-year period, 1912 to 1919, inclusive, the White Russian variety averaged 51.7 bushels per acre. This was higher than any of the other varieties grown during the period. The average yield of White Russian during the 5-year period, 1915 to 1919, inclusive, was 57.9 bushels per acre. A panicle and spikelets of the White Russian oat are shown in figure 16. During this same period the Silvermine variety averaged 58.2 bushels per acre. Panicles and spikelets of the Silvermine and Swedish Select varieties are shown in figure 17. The Sixty-Day variety averaged only 47.3 bushels. These yields are shown graphically in figure 18.

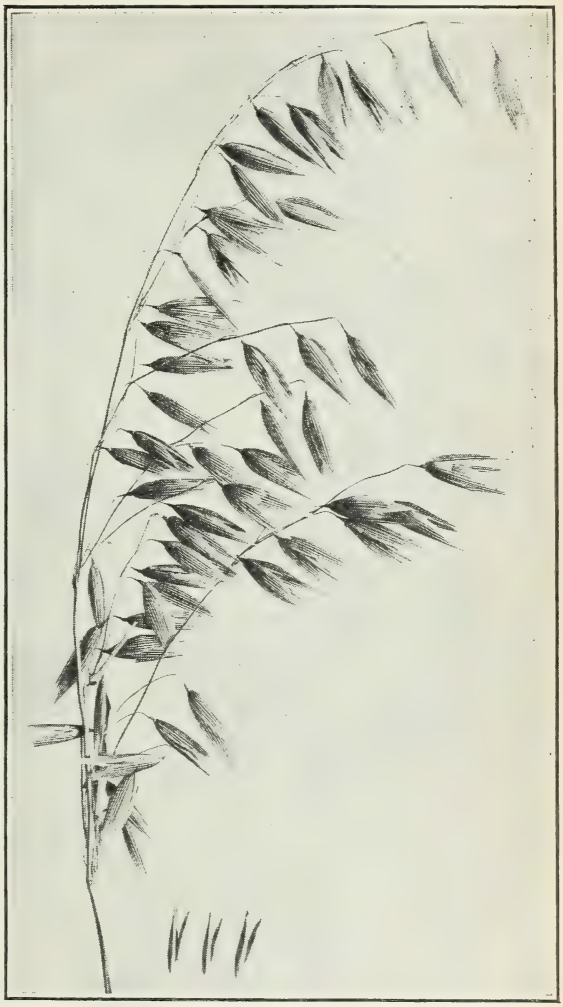

FIG. 16.—Panicle and spikelets of the White Russian oat.

Early oats do not appear to be well adapted to the irrigated land at Newell.

The Sixty-Day oat is a small, short-strawed, yellow variety which matures very early. It matures too early to make the best use of the irrigation water supply, but is well adapted to the dry land. Because of its slow maturity the White Russian, a late side or horse-mane oat, is able to utilize the soil moisture and to occupy more of the growing season. Of the midseason varieties, Silvermine has given the highest yields and is perhaps the best variety for the irrigated lands. Several other midseason varieties, such as Canadian and Swedish Select, produce large, plump grains, but the average yields have been less than White Russian and Silvermine.

FIG. 17.—Panicles and spikelets of oats, two varieties; *1*, Silvermine; *2*, Swedish Select.

TABLE XXXIX.—*Yields of the oat varieties grown on irrigated land on the Belle Fourche Experiment Farm, 1912 to 1917, inclusive.*

Group and variety.	C. I. No.	Yields per acre (bushels).									
		1912	1913	1914	1915	1916	1917	1918	1919	Average 1912 to 1919	1915 to 1919.
Early:											
Sixty-Day	165	25.0	47.1	32.5	34.0	28.8	51.5	75.0	47.2	42.6	47.3
Kherson	459	30.4	.....	.....	.....	.....	.....	.....	.....	.....	.....
Albion (Iowa No. 103)	729	.....	.....	.....	.....	20.2	.....	.....	.....	.....	.....
Richland (Iowa No. 105)	787	.....	.....	.....	.....	18.1	.....	.....	.....	.....	.....
Midseason:											
Swedish Select	134	35.2	33.0	41.6	46.5	39.6	54.6	77.9	52.1	47.2	54.1
Canadian	444	31.2	39.3	42.4	44.7	25.9	65.8	85.2	50.5	48.1	54.4
Lincoln	781	.....	.....	.....	50.7	36.1	52.8	74.2	.....	.....	.....
Silvermine	782	.....	.....	.....	52.3	41.6	61.1	79.2	56.8	.....	58.2
Pete Edwards [a]	778	.....	.....	50.7	51.8	37.4	57.8	73.7	61.0	.....	56.3
Abundance	780	.....	.....	.....	.....	35.3	57.0	72.7	.....	.....	.....
Great Dane	.....	.....	.....	32.8	.....	.....	.....	.....	.....	.....	.....
New White Danish	.....	.....	.....	.....	.....	34.8	.....	.....	.....	.....	.....
Late:											
Mammoth Cluster	779	.....	.....	43.7	.....	24.7	.....	.....	.....	.....	.....
White Russian	551	41.4	33.7	48.6	52.8	42.1	56.2	75.3	63.0	51.7	57.9
White Tartarian	300	46.8	.....	.....	.....	.....	.....	.....	.....	.....	.....

[a] A local variety of the Swedish Select type.

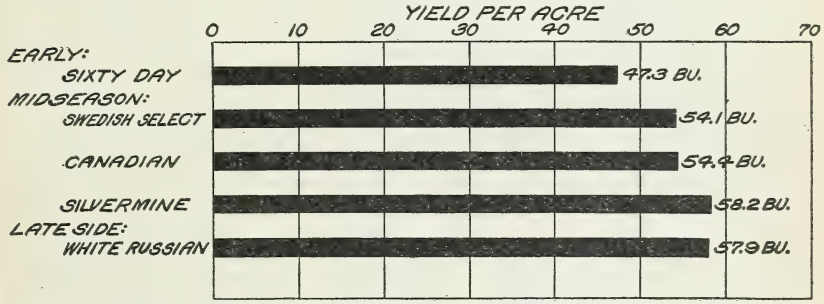

FIG. 18.—Diagram showing the average yields, in bushels per acre, of five varieties of oats on irrigated land at the Belle Fourche Experiment Farm for the 5-year period from 1915 to 1919, inclusive.

TABLE XL.—*Average agronomic data of oat varieties grown on irrigated land on the Belle Fourche Experiment Farm, 1912 to 1917, inclusive, and in 1919.*

Group and variety.	C. I. No.	Date of—		Height.	Weight per bushel.	Yields per acre.	
		Heading.	Maturity.			Grain.	Straw.
Early yellow:				*Inches.*	*Pounds.*	*Bushels.*	*Pounds.*
Sixty-Day	165	July 4	July 26	26	32.7	38.0	1,035
Midseason white:							
Canadian	444	July 13	Aug. 2	33	36.3	42.7	1,498
Swedish Select	134	July 14	Aug. 5	31	34.9	42.8	1,408
Late side:							
White Russian	551	July 19	Aug. 13	33	33.7	48.3	1,793

Table XL shows the average dates of heading and maturity, height, weight per bushel, and yields of grain and straw of the four oat

varieties grown from 1912 to 1919, inclusive. The results for 1918 are not included. During this period the Sixty-Day variety matured 7 days earlier than Canadian, 10 days earlier than Swedish Select, and 18 days earlier than White Russian. The Sixty-Day oat was also shorter and had a lower weight per bushel than the other varieties.

RATE-OF-SEEDING EXPERIMENTS.

Silvermine oats were grown in rate-of-seeding experiments at Newell in 1918 and 1919. The seed was sown at four different rates, viz, 6, 8, 10, and 12 pecks per acre, in triplicated fiftieth-acre plats. The yields are shown in Table XLI.

TABLE XLI.—*Yields of Silvermine oats grown in rate-of-seeding experiments on irrigated land on the Belle Fourche Experiment Farm in 1918 and 1919.*

Rate of seeding per acre.	Yields per acre (bushels).		
	1918	1919	Average.
6 pecks	77.1	58.5	67.8
8 pecks	79.9	61.7	70.8
10 pecks	73.2	64.6	68.9
12 pecks	69.6	63.3	66.5

The 8-peck seeding gave the highest yield in 1918 and the 10-peck seeding in 1919. The yields were good and quite uniform in both seasons. The average yield from the 8-peck seeding was 70.8 bushels and from the 10-peck seeding 68.9 bushels per acre, with the 6-peck and 12-peck seedings yielding slightly less. At Newell 8 pecks per acre seems to be sufficient seed for Silvermine oats, but for greater certainty of crop the seeding of 10 pecks per acre would be desirable.

EXPERIMENTS WITH BARLEY.

VARIETAL EXPERIMENTS.

Eleven varieties of barley have been grown on irrigated land at Newell. None of these were grown during all of the eight years from 1912 to 1919, but four varieties were grown continuously for six years. The yields in general were not very large, but good crops were harvested in 1915, 1917, and 1918. The yields are shown in Table XLII.

The Chevalier II variety produced the highest average yield, 38.5 bushels per acre, from 1914 to 1919, inclusive. This variety also gave the highest yield during the three years 1917 to 1919. A head of Chevalier II barley is shown in figure 19. The Trebi variety yielded nearly as well. The former is a late 2-rowed barley which is able to develop fully in the presence of sufficient soil moisture.

The Hannchen variety, which was grown during four of the eight years from 1912 to 1919, is slightly earlier than the Chevalier II, and it probably will yield nearly as well. The Chevalier II is a selected strain of the Chevalier, developed at the Svalof Experiment Station in Sweden. A field of Chevalier being irrigated is shown in figure 20.

The Trebi is the latest and also the highest yielding of the 6-rowed varieties grown. This variety is also well adapted to the irrigated sections of Idaho. The Coast variety yielded an average of 43 bushels per acre. This variety has strong persistent awns, which make it harder to thrash and less desirable for feeding than the other varieties. The grain has a bluish appearance. The different strains of Manchuria do not seem to be well adapted to the irrigated land at Newell, as the yields are less than from the other varieties. The Manchuria barley is the one most commonly grown throughout the Dakotas and Minnesota.

The Himalaya (or Guy Mayle) is a blue hull-less variety, having awned spikes. When the amount of hull on the hulled varieties is considered the Himalaya has yielded about as well as any of the 6-rowed

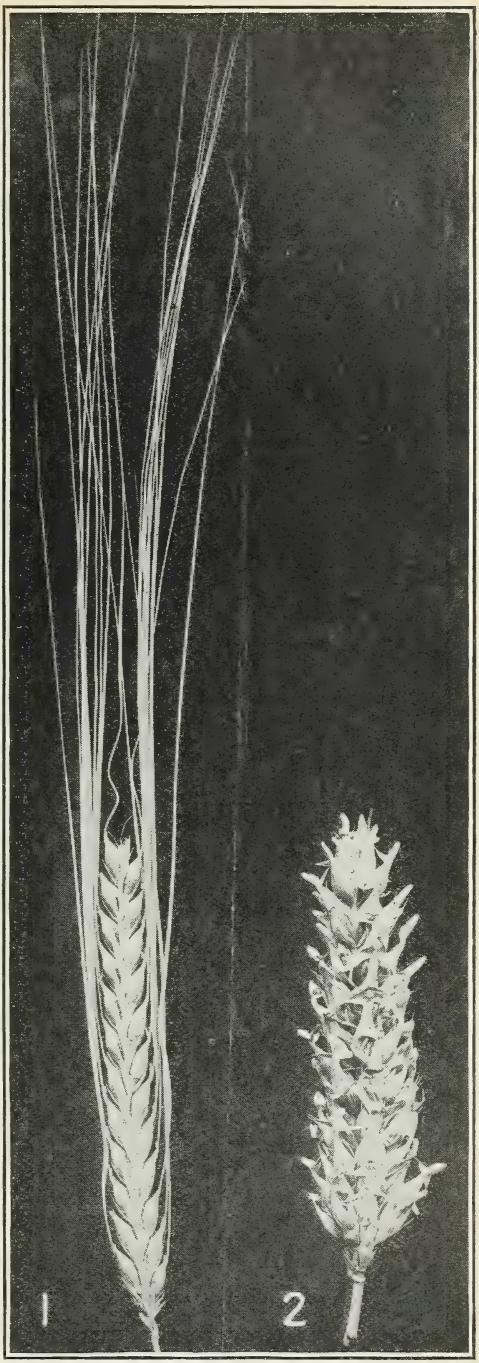

FIG. 19.—Heads of two varieties of barley: *1*, Chevalier; *2*, Nepal.

varieties with the exception of Trebi. The Nepal (White Hull-less) variety has not given good yields, its only advantage appearing to be the lack of awns. A head of Nepal barley is shown in figure 19.

FIG. 20.—Irrigating a field of Chevalier barley on the Belle Fourche Experiment Farm.

TABLE XLII.—*Yields of varieties of barley grown on irrigated land on the Belle Fourche Experiment Farm, 1912 to 1919, inclusive.*

Group and variety.	C. I. No.	Yields per acre (bushels).									
		1912	1913	1914	1915	1916	1917	1918	1919	Average. 1914 to 1919	Average. 1917 to 1919
Six-rowed, hulled:											
Coast	690	.....	.....	.....	23.0	15.2	37.9	65.6	25.4	.....	43.0
Manchuria (Wis. No. 13)	905	.....	25.8	21.8	20.9	14.7	23.9	66.7	17.7	27.6	36.1
Manchuria (Minn. No. 6)	638	16.9	.....	.....	.....	.....	.....	.....	.....	.....	.....
Manchuria (Minn. No. 105)	354	.....	23.5	17.8	.....	.....	.....	.....	.....	.....	.....
Odessa	182	17.4	.....	.....	.....	.....	.....	.....	.....	.....	.....
Trebi	936	.....	.....	.....	.....	.....	38.0	75.9	28.8	.....	47.6
Two-rowed, hulled:											
Chevalier	1162	.....	.....	26.8	37.2	23.2	.....	.....	.....	.....	.....
Chevalier II	530	13.0	.....	23.0	39.2	23.9	38.5	74.3	32.0	38.5	48.3
Hannchen	531	19.8	32.9	15.0	.....	25.1	40.7	.....	.....	.....	.....
Six-rowed, naked:											
Himalaya (Guy Mayle)	620	.....	.....	26.6	23.4	17.5	23.7	62.7	17.5	28.6	34.6
Six-rowed hooded, naked:											
Nepal (White Hull-less)	595	9.1	.....	19.2	20.4	14.9	22.3	51.6	18.4	24.5	30.8

Table XLIII shows the average dates of heading and maturity, height, weight per bushel, and yields of grain and straw of four varieties of barley grown from 1914 to 1917, inclusive, and 1919. The average yields of these four varieties are also shown in figure 21.

The Chevalier II is taller, later, and produces much higher yields than the other varieties.

TABLE XLIII.—*Average agronomic data of four varieties of barley grown on irrigated land on the Belle Fourche Experiment Farm, 1914 to 1917, inclusive, and in 1919.*

Group and variety.	C. I. No.	Date of—		Height.	Weight per bushel.	Yields per acre.	
		Heading.[a]	Maturity.[a]			Grain.	Straw.
				Inches.	*Pounds.*	*Bushels.*	*Pounds.*
Six-rowed, hulled: Manchuria	905	July 10	Aug. 7	26	47.7	19.8	1,145
Two-rowed, hulled: Chevalier II	530	July 17	Aug. 17	27	50.1	31.3	1,472
Six-rowed, naked: Himalaya	620	July 9	Aug. 4	23	60.0	21.7	995
Six-rowed, hooded, naked: Nepal	595	July 10	Aug. 6	25	60.3	19.0	917

[a] Average for four years, 1915, 1916, 1917, and 1919.

NURSERY EXPERIMENTS.

About 35 varieties of barley, representing a wide range of types, were grown in 17-foot rows under irrigation in 1917 and 1919. The

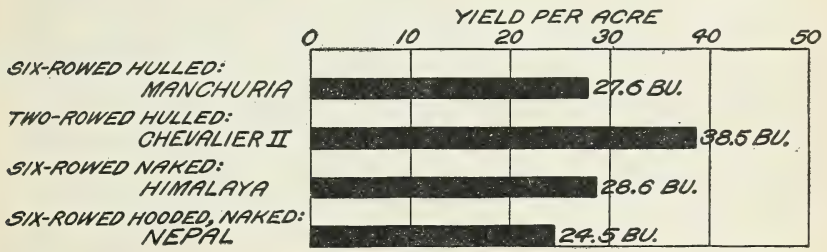

FIG. 21.—Diagram showing the average yields, in bushels per acre, of four varieties of barley on irrigated land at the Belle Fourche Experiment Farm for the 6-year period from 1914 to 1919, inclusive.

object was to observe the behavior of the varieties under irrigated conditions. In general the late varieties produced the highest yields, which was in accordance with the results from the plat experiments. Further tests would be necessary to determine definitely the yields in comparison with the varieties grown in plats.

EXPERIMENTS WITH MINOR CEREALS.

SPRING EMMER.

One variety of spring emmer, Vernal (White Spring), has been grown under irrigation each year in comparison with either the barley or oat varieties. The soil and preparation have been the same each year for both oats and barley, and usually spring wheat also, so that these crops can be compared directly with the emmer.

The yields of emmer have ranged from 24.5 bushels in 1912 to 88 bushels per acre in 1918, with an average of 48.1 bushels of 32 pounds each per acre. The yields of Vernal emmer in pounds per acre for the five years from 1915 to 1919, inclusive, are shown in Table XLVIII (p. 65), which gives a comparison of the yields of the grain crops. During this period Vernal emmer yielded an average of 1,911 pounds per acre, Kubanka wheat 1,667 pounds, Chevalier II barley 2,016 pounds, and White Russian oats 1,852 pounds. Emmer is used as a feed crop and thus competes only with barley and oats. The results obtained at Newell on irrigated land show that barley is a more profitable feed crop than emmer, and it also has a higher feeding value.

WINTER EMMER AND SPELT.

One variety of emmer (Buffum Black Winter) and one of spelt (Brown Winter) were grown on irrigated land along with the winter-wheat varieties in 1916 and 1917. Single plats of each were sown. During the winter of 1915–16 a part of these crops was winterkilled, so that the stands were thin. The emmer yielded at the rate of 425 pounds and the spelt 100 pounds per acre. Kharkof winter wheat in the same series yielded 678 pounds per acre. The winter of 1916–17 was more severe, and both the emmer and spelt were almost entirely winterkilled. The plats were disked to destroy weeds. Kharkof winter wheat in the same series yielded 1,394 pounds per acre. Neither winter emmer nor winter spelt are sufficiently hardy to be safely grown in western South Dakota. They yield less and are also less valuable than winter wheat.

RYE.

Two varieties of winter rye were grown in the experiments along with the winter-wheat varieties on irrigated land from 1915 to 1918, inclusive. The rye was sown at the rate of 5 pecks per acre. Winter rye is more hardy and consequently more certain than winter wheat. The yields obtained from the rye were less in pounds per acre than the wheat yields in all years. The average acre yield of the Swedish rye during the four years was 23.6 bushels of 56 pounds each, while Kharkof wheat during the same period averaged 32.6 bushels of 60 pounds each.

The North Dakota No. 959 rye averaged only 0.9 bushel per acre less than the Swedish. This was partly due to the former being on poorer land in 1915. The North Dakota No. 959 rye is probably the hardier, but both are sufficiently hardy for the climate at Newell.

The yields of rye in comparison with Kharkof winter wheat are shown in Table XLIV.

TABLE XLIV.—*Comparison of the yields of two varieties of winter rye and of Kharkof winter wheat on irrigated land on the Belle Fourche Experiment Farm, 1915 to 1918, inclusive.*

[Yields of wheat computed at 60 pounds per bushel, rye at 56 pounds per bushel.]

Crop and variety.	C. I. No.	Yields per acre (bushels).				
		1915	1916	1917	1918	Average.
Rye:						
Swedish (Minn. No. 2)	137	44.6	10.8	21.3	17.5	23.6
N. Dak. No. 959	175	[a] 38.8	11.7	25.4	14.8	22.7
Winter wheat:						
Kharkof	1583	66.3	11.3	29.5	23.4	32.6

[a] One plat only.

BUCKWHEAT.

Buckwheat was grown only in 1916 and 1917 on irrigated land. In 1916 a plat of about 0.15 acre was sown to buckwheat on May 31 at the rate of 6 pecks per acre. The seed was of the Japanese type obtained locally. The plants were in full bloom during the hottest weather and many of the flowers were blasted. Although considerable plant growth was made, the plat yielded at the rate of only 21.1 bushels per acre. In 1917 a plat containing about 0.9 acre was sown to buckwheat on June 16. The land was sloping and the buckwheat was injured by the soil washing at the first irrigation. The land also contained a considerable growth of volunteer barley, alfalfa, and weeds, which the buckwheat failed to check. The yield was 12.7 bushels per acre. Buckwheat is not as productive as other grain crops at Newell.

PROSO.

Proso was grown only in 1918 and 1919 on irrigated land. It is not well suited to irrigated conditions, and many other late sown crops doubtless are more profitable. The yields were not large during either season, and in 1919 the crop was damaged considerably by birds. Four varieties of proso were grown under irrigation, the yields of which are shown in Table XLV.

TABLE XLV.—*Yields of four varieties of proso grown on irrigated land on the Belle Fourche Experiment Farm in 1918 and 1919.*

Variety.	C. I. No.	Yields per acre (bushels).		
		1918	1919 [a]	Average.
White Ural	4	21.4	5.9	13.7
Hansen	179	15.5	5.7	10.6
Red Russian	61	27.1	16.5	21.8
Black Voronezh	27	25.9	11.6	18.8

[a] Damaged by birds in 1919.

The Red Russian variety gave an average yield of 21.8 bushels per acre, while the next highest variety, Black Voronezh, yielded 18.8 bushels per acre. The Hansen variety gave the lowest yields during both seasons.

EXPERIMENTS WITH GRAIN MIXTURES.

WHEAT, OATS, AND BARLEY MIXTURES.

Mixtures of grains, chiefly of barley and oats, have occasionally been grown by farmers. The mixtures are often referred to as "succotash." An experiment to determine the value of this practice of growing mixed grains on irrigated land was begun at Newell in 1915 and continued for three years, after which further experiments seemed to be unnecessary.

The varieties selected were the Chevalier II barley, Swedish Select oats, and Kubanka wheat. From past observations these varieties were known to mature at practically the same time if sown on the same date. This proved to be the case in these experiments. These varieties were well adapted to growing under irrigation, were not easily shattered at maturity, and were not subject to severe rust injury.

In the plats sown to the single grains the barley was sown at the rate of 6 pecks, the oats at 10 pecks, and the wheat at 5 pecks per acre. The grains were sown with a disk drill which, when set to sow the above quantities, was found from calibration tests to sow the proper measured quantity regardless of bushel weight. In preparing the mixtures the weights per bushel of the grain were first determined. The mixtures of two grains contained seed of each to sow half of the quantity of seed used for each grain when sown alone. The mixture of barley, oats, and wheat contained one-third of the quantity of seed used for each grain sown alone. The drill was calibrated for each mixture so as to sow the proper quantities of mixed grain. The proportions of each grain in the thrashed crop were not determined.

The yields of the mixed grains, the grains grown alone, and the average yields of the two or three grains grown alone are shown in Table XLVI.

Good yields of all grains were obtained in 1915 and 1917, but the yields in 1916 were reduced somewhat by soil blowing and rust. In 1915 about 10 per cent of the grain from the grains and mixtures was shattered by hail while standing in the shock. The barley had been thrashed before the hail, however, so the yield shown for 1915 has been reduced 10 per cent to make it comparable with the other grains.

TABLE XLVI.—*Yields of wheat, oats, and barley, separately and mixtures of these crops, grown on irrigated land on the Belle Fourche Experiment Farm, 1915 to 1917, inclusive.*

Crop and mixture.	Yields per acre (pounds).			
	1915	1916	1917	Average.
Barley	1,830	1,108	2,516	1,818
Oats	1,825	1,300	2,325	1,816
Wheat	1,641	1,083	2,391	1,705
Barley and oats	1,950	1,300	2,516	1,922
Barley and wheat	1,775	1,083	2,300	1,719
Oats and wheat	1,750	1,333	2,225	1,769
Barley, oats, and wheat	1,930	1,283	2,108	1,774
Averages of crops grown alone:				
Barley and oats	1,828	1,204	2,420	1,817
Barley and wheat	1,735	1,095	2,453	1,761
Oats and wheat	1,733	1,191	2,358	1,760
Barley, oats, and wheat	1,765	1,164	2,411	1,780

In 1915 all of the mixtures and in 1916 all of the mixtures except the barley and wheat showed higher yields than the averages of the crops grown alone. In 1917 the barley and wheat, oats and wheat, and the barley, oats, and wheat mixtures yielded less than the averages in the grains sown alone. The 3-year average yields show very little advantage in growing the grain mixtures. The barley and oats mixture yielded 105 pounds per acre more than the average of the two crops grown alone, but the other three mixtures yielded nearly the same as the averages of the same grains grown alone. Under the conditions of the experiment the growing of grain mixtures would not be advisable. If the varieties of the different crops had very different habits or periods of growth, increased yields from mixtures might be expected, but this would be offset by the difficulties and losses in harvesting.

WHEAT AND FLAX MIXTURES.

The experiments with mixtures of wheat and flax were begun in 1916. After the crops had emerged the severe soil blowing early in May destroyed nearly all of the flax plants, both in the mixtures and where sown alone. Most of the wheat plants survived, but the mixture experiment was of no value. The mixtures of wheat and flax were again sown in 1917 and 1918. The flax, Damont, C. I. No. 3, was sown at the rate of 15 pounds per acre, whether mixed with wheat or sown alone.

The wheat, Marquis, C. I. No. 3641, was sown at the rates of 37 pounds and 75 pounds per acre alone and mixed with flax. The almost total absence of weeds from the plats made the experiment of less value, because the object of the mixture of wheat and flax is to overcome or replace weeds. The relative quantities of wheat and flax produced in the mixtures were determined only in 1917.

The yields of the wheat, flax, and the mixtures of both are shown in Table XLVII.

TABLE XLVII.—*Yields of flax and wheat separately and mixtures of these crops grown on irrigated land on the Belle Fourche Experiment Farm in 1917 and 1918.*

Crop.	Rates of seeding and yields per acre (pounds).			
	Seeding.	Yields.		
		1917	1918	Average.
Flax	15	941	867	904
Mixture {flax / wheat	15 / 37	1,150	1,408	1,279
Wheat	37	1,100	1,308	1,204
Mixture {flax / wheat	15 / 75	1,425	1,467	1,446
Wheat	75	1,300	1,442	1,371

Larger total yields of wheat and flax were obtained from the mixtures than from either crop grown alone. Wheat predominated in the mixtures. The value of the practice of growing the mixture of wheat and flax will depend on the relative prices and yields of the two crops. The cost of separating the thrashed crop must also be considered. It was necessary to let the wheat stand for some time after it was ripe before the flax could be harvested, and it was also rather difficult to thrash the flaxseed without cracking many of the wheat grains.

COMPARISON OF GRAIN CROPS.

In 1912, 1913, and 1914 the only small grains grown in the cereal experiments under irrigation were spring varieties of wheat, oats, barley, and emmer. In 1915 and since several additional grains have been grown. The annual and average yields of the leading varieties of each of the grains grown in 1915 and later are shown in Table XLVIII.

Winter wheat and winter rye were grown during only four of the five years from 1915 to 1919, inclusive, while winter spelt, winter emmer, proso, and buckwheat were grown only two years each. In terms of pounds of grain per acre, winter wheat gave the highest yield in 1915, oats in 1916 and 1919, spring wheat in 1917, and barley in 1918. Chevalier II barley has outyielded all other grains during both the 4-year and the 5-year periods, for which the average yields are shown in Table XLVIII. Vernal spring emmer and White Russian oats gave the next highest yields of grain. Winter emmer, win-

ter spelt, proso, and buckwheat produced rather low yields and are not well adapted to growing at Newell under irrigation, and none of these four crops except proso are at all adapted to the dry-land conditions there.

TABLE XLVIII.—*Yields of the leading varieties of different grain crops grown on irrigated land on the Belle Fourche Experiment Farm, 1915 to 1919, inclusive.*

Group and variety.	C. I. No.	Yields per acre (pounds).						
		1915	1916	1917	1918	1919	Average. 1915 to 1918	Average. 1915 to 1919
Kharkof winter wheat	1583	[a] 3,976	678	1,770	1,394	.....	1,955	.....
Swedish (Minn. No. 2) winter rye	137	[a] 2,496	655	1,192	980	.....	1,331	.....
Buffum Black Winter emmer	3331	.....	425	0	.....	.....	.....	.....
Vernal spring emmer	1524	1,855	1,141	1,845	2,816	1,900	1,914	1,911
Kubanka durum spring wheat	1440	1,320	1,248	1,968	2,016	1,782	1,638	1,667
Brown Winter spelt	.....	.....	100	0	.....	.....	.....	.....
Chevalier II barley	530	1,881	1,150	1,848	3,567	1,536	2,112	2,016
White Russian oats	551	1,690	1,347	1,798	2,410	2,016	1,811	1,852
Red Russian proso	61	.....	.....	.....	1,518	924	.....	.....
Japanese buckwheat	.....	.....	1,042	609	.....	.....	.....	.....

[a] Not comparable with spring grains; grown on better soil.

EXPERIMENTS WITH FLAX.

Flax has been a fairly successful crop on irrigated land. It also is an excellent nurse crop for alfalfa. The yields obtained at Newell

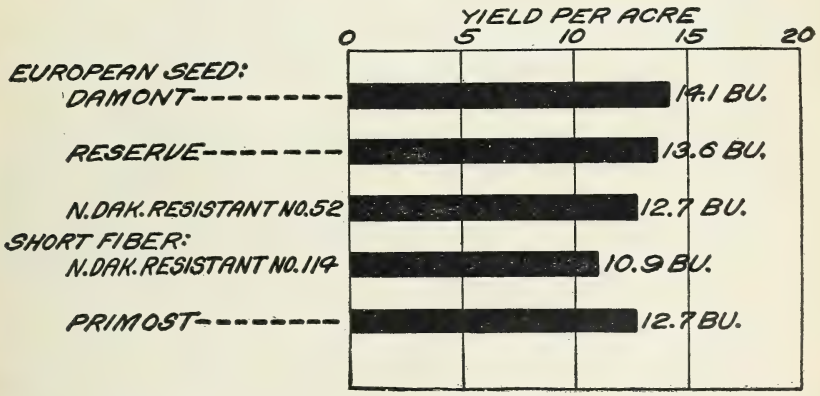

FIG. 22.—Diagram showing the average yields, in bushels per acre, of the leading varieties of flax on irrigated land at the Belle Fourche Experiment Farm for the 6-year period from 1914 to 1919, inclusive.

were fairly good except in 1913 when the flax was grown on poor land. Some infection of wilt and canker has been observed in the experiments, but the injury usually was very slight. A spot about 8

feet in diameter, mostly in a plat of North Dakota Resistant No. 52, was made almost bare by wilt in 1916. The same land had produced flax in 1914.

VARIETAL EXPERIMENTS.

Varietal experiments with flax on irrigated land were begun in 1912. Ten varieties have been grown, three of them during each of the eight years. Five varieties were grown during the six years from 1914 to 1919, inclusive. All varieties were of the blue-flowered, brown-seeded type. The yields of the flax varieties are shown in Table XLIX. The average yields of five varieties are also shown graphically in figure 22.

TABLE XLIX.—*Yields of flax varieties grown on irrigated land on the Belle Fourche Experiment Farm, 1912 to 1919, inclusive.*

Group and variety.	C. I. No.	Yields per acre (bushels).									
										Average.	
		1912	1913	1914	1915	1916	1917	1918	1919	1912 to 1919	1914 to 1919
European seed:											
Russian (N. Dak. No. 608)	1	.....	.....	3.7	.....	.....	.....	.....	.....	.....	.....
Damont (N. Dak. No. 1215)	3	.....	.....	11.8	14.5	10.7	15.1	21.7	10.7	.....	14.1
Frontier (Russian)	17	10.1	.....	.....	.....	.....	.....	.....	.....	.....	.....
Reserve (Russian)	19	12.5	5.3	10.0	14.1	12.7	13.6	19.1	11.9	12.4	13.6
N. Dak. Resistant No. 52	8	11.9	4.8	5.8	13.6	10.7	12.9	20.8	12.2	11.6	12.7
Common	.....	11.3	.....	.....	.....	.....	.....	.....	.....	.....	.....
Short fiber:											
N. Dak. Resistant No. 114	13	.....	.....	11.1	12.4	6.5	11.4	15.5	8.6	.....	10.9
Primost (Minn. No. 25)	12	11.1	5.3	11.6	12.9	9.0	10.0	20.5	12.2	11.6	12.7
Turkish:											
Turkish	7	.....	4.4	1.5	.....	.....	.....	.....	.....	.....	.....
Smyrna	30	.....	.....	.....	6.0	4.1	.....	.....	.....	.....	.....

The Damont and Reserve varieties have produced the highest yields, the former averaging 14.1 bushels and the latter 13.6 bushels per acre. Both of these varieties are rather tall, with medium-large seeds. The Primost and North Dakota Resistant No. 114 varieties belonging to the short-fiber group have short stems and small, dark-brown seeds. Neither of the wilt-resistant varieties grown produced the highest yields, because of the almost total absence of wilt.

The two varieties of the Turkish group, Turkish and Smyrna, which were grown in the experiments produced relatively low yields and were almost too short to harvest with the binder.

Table L shows the average dates of heading and maturity, height, weight per bushel, and yields of seed and straw of three varieties of flax grown from 1914 to 1919, inclusive. The Damont was one and two days, respectively, later than the North Dakota Resistant No. 52 and Primost varieties. The average height apparently is the same

for all three varieties, but in general Primost is somewhat shorter than the other two. The weight per bushel of the three varieties is about the same.

TABLE L.—*Average agronomic data of three varieties of flax grown on irrigated land on the Belle Fourche Experiment Farm, 1914 to 1917, inclusive, and in 1919.*

Group and variety.	C. I. No.	Date of—		Height.[a]	Weight per bushel.	Yields per acre.	
		Full bloom.[a]	Maturity.			Seed.	Straw.
European seed:				*Inches.*	*Pounds.*	*Bushels.*	*Pounds.*
Damont	3	July 13	Aug. 6	20	54.3	12.6	1,027
N. Dak. Resistant No. 52	8	July 11	Aug. 5	20	54.5	11.0	949
Short fiber:							
Primost (Minn. No. 25)	12	July 10	Aug. 4	20	54.3	11.1	891

[a] Average for 1915, 1916, 1917, and 1919.

NURSERY EXPERIMENTS.

Several varieties of flax were grown in 17-foot rows under irrigation for preliminary testing during the 5-year period, 1915 to 1919. None of these yielded as well as varieties already being grown in plats. Some selections of Smyrna flax, C. I. No. 30, were made in 1915 to increase the height of the variety. Strains of the parent type 1 to 2 inches higher than the parent variety were isolated, but the yields were not sufficiently large to justify their being increased.

RATE-OF-SEEDING EXPERIMENTS.

Rate-of-seeding experiments with Damont flax on irrigated land were begun in 1916 in single fiftieth-acre plats. In 1917, 1918, and 1919 the experiment was triplicated. Good yields were obtained in all years. The flax was sown at three different rates during each of four years, with an additional rate in 1918. The yields are shown in Table LI.

TABLE LI.—*Yields of Damont flax grown in rate-of-seeding experiments on irrigated land on the Belle Fourche Experiment Farm, 1916 to 1919, inclusive.*

Rate of seeding per acre.	Yields per acre (bushels).				
	1916	1917	1918	1919	Average.
15 pounds	10.7	13.8	17.7	10.7	13.2
22½ pounds	.....	.....	21.1	.....	.....
30 pounds	10.2	15.2	23.7	13.7	15.7
45 pounds	11.0	14.2	23.4	13.8	15.6

The highest average yield was obtained from the seeding of 30 pounds per acre. The 45-pound rate yielded 0.1 bushel per acre

less, while the 15-pound rate yielded an average of 2.5 bushels per acre less than the 30-pound rate. The best rate of seeding for irrigated flax on a clean, well-prepared seed bed apparently is about 30 pounds per acre, but under less favorable conditions more seed might be desirable.

DATE-OF-SEEDING EXPERIMENTS.

Damont flax was grown in date-of-seeding experiments from 1916 to 1919, inclusive. Because of seasonal irregularities, especially spring rains, it was not possible to sow the flax on the exact dates planned. Seedings were made on three dates in 1916 and on five dates during each of the other three years. The experiment usually was conducted in duplicate. Good yields were obtained each year. The yields are shown in Table LII.

TABLE LII.—*Yields of Damont flax grown in date-of-seeding experiments on irrigated land on the Belle Fourche Experiment Farm, 1916 to 1919, inclusive.*

Date seeded.	Yields per acre (bushels).					
					Average.	
	1916	1917	1918	1919	1916 to 1919	1917 to 1919
April 15 to 23	8.4	.....	23.7	13.4	.....	.....
May 1 to 8	.....	16.9	24.9	13.0	.....	18.3
May 15 to 26	11.6	12.3	23.2	12.5	14.9	16.0
June 1 to 10	12.5	14.2	20.4	12.1	14.8	15.6
June 15 to 20	.....	10.7	14.6	12.1	.....	12.5
June 30	.....	5.3	.....	.....	.....	.....

The highest yield was produced by the latest date of seeding in 1916, the earliest date in 1917 and 1919, and the second earliest date in 1918. The results are somewhat inconclusive, but in general early seeding is somewhat more favorable for flax. The highest average yield for the 3-year period from 1917 to 1919, inclusive, was obtained from the seeding of May 1 to 8. The later dates of seeding produced progressively lower yields. Fair yields of flax from late seeding may be obtained in some years. The seeding of June 30, in 1917, was fully matured, but yielded only 5.3 bushels per acre. The flax was damaged considerably in irrigating, however. When possible, flax probably should be sown on irrigated land at Newell not later than the first week in May.

LATE IRRIGATION EXPERIMENT.

Irrigation of flax after it is in full bloom has been supposed to be detrimental, as it causes a renewed or second blooming and delays the maturity of the seed. In 1916, a single twentieth-acre plat of

Primost flax, C. I. No. 12, was given a late irrigation on July 25, while an adjoining plat of the same size was not irrigated. Both had been irrigated 15 days previous. When this late irrigation was applied the flax had practically completed blooming and most of the bolls were formed.

The late irrigation caused considerable late blooming, perhaps a third more than occurred on the check plat. Maturity was delayed only three days as compared with the check plat not irrigated. The plat receiving the late irrigation yielded at the rate of 15.7 bushels per acre, while the adjoining plat yielded only 13.3 bushels. The season was dry and warm, so that the increased soil moisture proved to be beneficial. This might not always occur, but it indicates that flax may be irrigated after blooming in most seasons without injury.

TILLAGE EXPERIMENTS.

Most of the spring grains under irrigation were sown on disked corn ground. The soil was a heavy clay and usually quite compact at the time of seeding, even after being double disked and harrowed. An experiment in tillage treatment of corn ground in preparation for spring grain was conducted during the 1915–16 crop year. The plats were all one-fiftieth of an acre in size.

Thirteen plats were plowed in the fall to a depth of 7 or 8 inches, 13 were subsoiled about 12 inches deep in the fall, while the 13 remaining were not touched until spring. Plowing was done with a disk plow. The subsoiler was run twice between the rows of corn stubble on unplowed land. In the spring all plats were double disked and floated alike and all subsequent treatment of the plats was the same.

The plats were sown to Kubanka wheat, Swedish Select oats, Chevalier barley, and Primost flax. Three plats each of wheat, barley, and flax and four plats of oats were sown on ground representing the three different tillage treatments, making a total of 39 plats in the experiment. Because of soil blowing, rust, and the presence of considerable wild oats, the yields obtained were not large. The yields from the experiment are shown in Table LIII.

TABLE LIII.—*Yields of spring wheat, oats, barley, and flax grown following a corn crop in a tillage experiment on irrigated land on the Belle Fourche Experiment Farm in 1916.*

Fall tillage.	Yields per acre (bushels).			
	Kubanka wheat.	Swedish Select oats.	Chevalier barley.	Primost flax.
Plowed	16.7	40.6	18.5	9.7
Subsoiled	16.3	39.8	18.1	9.4
None	17.8	41.1	19.6	10.2

The differences in yields obtained from the three tillage treatments are rather small. However, the results were the same for all four crops. In all cases the plats receiving no tillage treatment in the fall gave the highest yields, the plowed plats gave the next highest, and the subsoiled plats the lowest yields. Under the conditions of the experiment, plowing or subsoiling of corn ground in preparation for spring grain proved to be harmful rather than a benefit. The results are not entirely conclusive, because of having been obtained for only one year.

SUMMARY.

The experiments here reported were conducted on dry land during the 12 years from 1908 to 1919, inclusive, and on irrigated land during the 8 years from 1912 to 1919, inclusive.

The Belle Fourche Experiment Farm is located in the western part of South Dakota, about 30 miles northeast of the Black Hills. The results obtained are applicable to western South Dakota and adjoining sections in northeastern Wyoming, southeastern Montana, and southwestern North Dakota.

The soil on which these experiments were conducted is a heavy, impervious clay, or gumbo, known as Pierre clay.

The average annual precipitation for the 12 years was 14.31 inches and the seasonal precipitation, March to July, inclusive, averaged 8.57 inches. The annual precipitation ranged from 6.64 inches in 1911 to 21.02 inches in 1915. The seasonal precipitation is an important factor influencing the yields of grain. The average yields of the best varieties of wheat, oats, and barley on dry land have been fairly satisfactory, but partial or complete failures in some years have made grain growing uncertain. Other small grain crops are not as successful as wheat, oats, and barley.

Durum wheats have given higher yields than common spring wheat. Kubanka is the highest yielding variety. Marquis has given the highest yields of any of the common spring-wheat varieties. Kubanka wheat should be sown at the rate of about 4 pecks per acre on an ordinary seed bed. The wheat should be sown as early as weather and soil conditions permit.

The hard red winter wheats, Turkey and Kharkof, have produced the highest yields of the winter varieties. These two varieties are of equal value and are apparently identical.

Seeding at the rate of 4 pecks per acre has given the highest net yields on fallowed land. The best date of seeding for winter wheat is about September 16. Early-sown wheat does not survive the winter better than late-sown wheat.

Winter wheat has produced higher average yields than spring wheat, but is rather uncertain on account of winterkilling and soil blowing.

Spring emmer has not yielded as well as the best varieties of oats and barley. It is not resistant to extreme drought. Winter rye has yielded less than winter wheat, but it is hardier and more certain. Winter emmer and winter spelt are not hardy enough to be grown successfully in western South Dakota.

The early varieties of oats, Kherson and Sixty-Day, have given the highest yields. These varieties should be sown at the rate of 6 pecks per acre.

White Smyrna and Hannchen are the highest yielding varieties of barley on the dry land. The barley should be sown at the rate of 4 to 6 pecks per acre.

Red Russian proso has given the highest yields in plat experiments, and the Turghai in nursery experiments. Seeding proso in ordinary drill rows at the rate of 25 to 30 pounds per acre has given the highest yields.

Grain sorghums mature too late and require too much warm weather to be successfully grown at Newell. Manchu Brown kaoliang is the most certain of the grain sorghums yet grown there.

Damont (Select Russian) flax has given the highest yields. Reserve (N. Dak. No. 155) is the next best variety. The best rate of seeding for flax on dry land is about 2 pecks per acre. Flax should be sown before May 15.

The following varieties of grain are recommended for growing on dry land:

Spring wheat.—Kubanka, Marquis.
Winter wheat.—Turkey or Kharkof.
Oats.—Kherson or Sixty-Day.
Barley.—White Smyrna, Hannchen.
Proso.—Red Russian, Turghai.
Flax.—Damont, Reserve.

On irrigated land the Kubanka variety has produced the highest yields of spring wheat. Of the common spring wheats Marquis is perhaps the best, although Power and Champlain have given slightly higher average yields.

The hard red winter varieties, Turkey and Kharkof, are the best winter wheats for irrigated land. A selection from Turkey has produced the highest yields of the winter-wheat varieties.

Kharkof winter wheat should be sown at the rate of 5 pecks per acre on irrigated land. The best depth of seeding winter wheat is about 1½ inches.

Winter wheat has yielded slightly more than spring wheat under irrigation.

Spring emmer has yielded less than the best varieties of barley on irrigated land. Winter emmer and spelt are not hardy and give

small yields on irrigated land. Winter rye is not as productive as winter wheat. Buckwheat has not given good yields on irrigated land at Newell.

The highest yielding varieties of oats on irrigated land are Silvermine and White Russian. The Silvermine oat produced the highest yields when sown at the rate of 8 pecks per acre.

Chevalier II and Trebi barley have yielded best under irrigation.

Proso is not a very successful crop on irrigated land.

Mixtures of wheat, oats, and barley have not produced significantly higher yields of grain than the average of the crops grown alone. Mixtures of wheat and flax have yielded more than the crops grown alone, but wheat predominates in the mixture.

The Damont and Reserve varieties of flax have given the highest yields on irrigated land. These varieties also yielded best on the dry land. Flax under irrigation should be sown at the rate of 30 pounds per acre. Flax sown between May 15 and 26 produced the highest average yields on irrigated land.

Corn ground should not be plowed or subsoiled before being sown to small grains or flax.

The following varieties of grain are recommended for growing on irrigated land:

Spring wheat.—Kubanka, Marquis.
Winter wheat.—Turkey or Kharkof.
Oats.—Silvermine, White Russian.
Barley.—Chevalier, Trebi.
Flax.—Damont, Reserve.

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